Navigational patterns in interactive multimedia

Thesis

NAVIGATIONAL PATTERNS

IN INTERACTIVE MULTIMEDIA

by

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A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

The Open University

April 2006

Abstract

The central purpose of this thesis is to investigate whether users have distinct preferences for specific navigational patterns in multimedia: that is preferences for moving through multimedia. Subsidiary questions are whether users have preferences for working strategies, (the mental approach to investigating software) whether these preferences are similar for specific groups and whether these preferences are affected by the software's system and navigational design. Four groups were investigated within two ranges: children to adults, and novices to experts. The literature review revealed four different perspectives of investigating navigation: user, designer, pedagogy and human computer interaction and although this research concentrates on the first two perspectives the other two are integral and of equal importance.

Two empirical studies elicited the navigational information. The first studied pairs of children undertaking set tasks in multimedia, and demonstrated that although each pair had definite preferences, each group did not utilise the full pattern range discerned from the observations, literature review and multimedia package analysis. The second study was redesigned using individual adults to ascertain the full range of preferred patterns in use. The essential element from the investigations was the wide range of variation between individuals and within groups. There was a gradual progression in their range and speed using these patterns, related to their skills, abilities and experience, and each individual could be placed along a continuum. Topologies of the multimedia packages and diagrams of the fit of the navigation patterns were included. Finally an expert panel was convened to verify the pattern range and their comments supported the new classification.

The research outcomes included navigational patterns and working strategies classifications, future techniques for designers, and user methods. These will create more successful and informed multimedia, and forward developments and improvements in the design of high quality user preference software.

Preface and Acknowledgements

The structure and methodology of the thesis have undergone various changes through the course of the research work. The research was initially based in educational technology, but I was coming from a background of electronic publishing and teaching in multimedia to publishers who were interested in the content of the multimedia rather than the way it was used. By the end of the research I was employed and working in a much more computer orientated academic environment, which altered the course of the research and focussed it within the human computer interaction area. This concentration on human computer interaction and research on how people used software, as well as developing software and assessing its use through a working environment, changed the main issue of the research into the effect software design has on both the user and the designer. The thesis perspectives reflect these changes of views through time. The views expressed since commencing the research have profoundly affected the thesis' outcomes, and the subsequent development of, and interest in, human computer interaction research has influenced the writing up of this research.

Additionally starting from within the Institute of Educational Technology at the Open University and having discussions with a whole range of people there, including wider Open University contacts, has affected the research. These contacts and discussions included Diana Laurillard, Tim O'Shea, Eileen Scanlon, Simon Buckingham Shum, Josie Taylor, Ann Jones and John Richardson among many others. External contacts at other universities within and outside the UK that I would like to thank include Lucy Suchman, Ron Oliver, Ben Shneiderman, David Jonassen, Ian Hurt, John Self, Russel Winder and Alfred Bork. These contacts and conversations have contributed to several changes of direction or emphasis within the research and iterations of the final written work. However the final version represents a distillation of the most important elements in a condensed form.

I would also like to thank the software companies and publishers who have given me free use of the multimedia packages in particular Mindscape who offered me everything in their catalogue, the BBC, and the British Library, who were very receptive of my comments on Medieval Realms and put them into practice.

The author wishes to thank all the people who have contributed to this research especially all the children and adult volunteers who took part in the multimedia sessions. In particular I would like to thank all the staff at the Open University who have offered advice and help.

I would like to thank the external examiner Professor Stephen Payne and the internal examiner Dr. Patrick McAndrew for their time and effort in their careful examination of the thesis and their helpful and constructive comments.

I would especially like to thank my first two supervisors, Dr. Josie Taylor and Dr. Ann Jones for their friendly and helpful advice and support over several years of full time and then part time study as well as their understanding of the balancing act between working full time, having a family and completing a PhD!

I would like to give many thanks to Professor John Richardson who took over as supervisor during the writing up, for his help with the drafts and final version, and preparation for the viva and amendments. I welcomed his methodical and systematic working through the thesis, attention to detail and continued unflagging support and encouragement.

Finally I would like to thank my family, my husband Tony, and my children James, Thomas, Zachary and Anouschka who have all grown much bigger and wiser during the time it has taken. I may have finished it quicker without them but life wouldn't have been anywhere near so much fun.

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GLOSSARY

Multimedia - the presentation of information by a computer system using graphics, animation, sound and text

Navigation - the methods used to move through the multimedia resource

Navigational pattern – the physical route taken by the user through the software package while navigating through the various screens/ videos/ demonstrations / graphics/ and sound

Working strategies – the methods users employ to work through multimedia software – the mental path the user develops

Hypertext /hypermedia - the non-linear organisation of data on a computer, usually in predefined stacks with each node separately accessible

Expert or skilled user - this refers to someone who is experienced and competent in the use of computer software, possibly with multimedia, e.g. a computer science professional

Intermediate user - a user who has limited experience of using the computer and multimedia, and who has developed some skills in using software

Novice or unskilled user - a person who is new to computing, or has some basic computer experience but no multimedia experience

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Introduction

1.1 Introduction

Central to this thesis is the argument that individuals have distinct preferences for certain types of navigational patterns, and that these can be both identified and classified through the use of observational empirical research. The effect of software design on user's navigational patterns will be analysed. The extent to which there were differences in the navigational patterns between different groups, such as between children and adults, and novices and experts is investigated. In addition the thesis will seek to demonstrate that navigational preferences shape both the user's approach to using software and the working strategies that they employ. The significance and implications of the central argument are fourfold.

First, by allowing users to follow their own individual navigational preferences, users will achieve optimum benefit from using multimedia packages – the user perspective.

Second, multimedia packages need to be designed in order to take account of navigational preferences and working strategies – the designer perspective.

Third, recognition of this argument means the multimedia will be used in the most effective way to achieve the end goals or the package designer's educational intent – the pedagogic perspective.

Fourth, information on how the user navigates through the software and their skills, abilities and knowledge in navigating should inform human computer interaction (HCI) research and produce more user centred and better designed software – the HCI perspective.

Although this thesis concentrates on the user's and designer's issues and discusses these in detail, these are precursors to the pedagogic and human computer interaction perspectives, but they are all integral and the research will elucidate the latter two for future more detailed research. The research reported in the thesis focuses on observing users using multimedia, and information was collected on how users approached the software. The research determined whether there were personal preferences by comparing the navigational routes selected, and then discussing these routes with the user. The navigational patterns and working strategies were looked at in terms of variances in the preferences of patterns within groups (children/adult, novice/expert) and whether these were recognisable and different. Each individual's navigational preferences became more crucial during the course of this research, as it was considered after the first study that delineating each user's portfolio of preferences, and developing their awareness of them, would allow expansion of each user's knowledge and working methods. The increasing significance of the variation between users through the initial research, and the relative lack of variance between the first study children using multimedia meant that the direction of the research was changed for the second study. This second study concentrated on investigating and analysing the navigational patterns of adults as it was thought that there would be a greater variety and richness with adult users. Only by studying a very diverse group would it be possible to discover the full range of potential patterns and to develop these into a workable classification.

1.2 The present state of navigational research

This importance of the user, and user-centred approach to design has several advocates. Marchionini (1989) discussed hypermedia as an enabling rather than a directive technology:

> Learners can construct their own knowledge by browsing hyper-documents according to the associations in their own cognitive structures (p.167).

Although research in methods and strategies employed in using and navigating in multimedia has been limited, it is now increasing, but there is still relatively little on multimedia, and so relevant hypermedia work has been included. Barab, Fajen, Kulikowich and Young (1996) reviewed an individual's navigation patterns in hypermedia, and expressed the need for more research in specific navigational methods:

> In terms of its applications, future research should continue to compare navigational paths of various groups of individuals (p.203).

This linked the need for the user to relate new knowledge with their own prior knowledge, emphasised the skills and abilities that the user brought with them to the next computer session. Ayersman (1996) commented on the user and made three relevant points: 1) Users chose different paths, different media, tools and aids to get to the same end, 2) Options and greater levels of user control allowed users to select their preferred approach and 3) User control allowed a) learner empowerment and b) individual differences to be beneficially addressed. Whalley (1990) considered that the most successful hypertext involved learners and led them to adopt the most appropriate strategies for their task. Taylor and Laurillard (1994) looked at specific issues such as: knowing how to ask the right questions, specifying goals, realising overall aims, evaluating their progress and maintaining motivation, which developed the skills and abilities of the individual. Arents and Bogaerts (1993) commented on user's navigation and their needs:

> If navigation is to be made more efficient and effective the system mechanisms supporting this navigation have to be made more responsive to the needs of the reader, the types of information available, and the characteristics of the tasks the reader wants to accomplish using that information (p.187).

1.3 The user's perspective

Investigations into navigational patterns by researchers such as Horney (1993), and Canter, River and Storrs (1985), recorded and discussed the individual user's navigational paths. These two research projects have been appropriate for this thesis, and formed the basis of the navigational patterns research from the users' perspective. The range of methods used to investigate navigational routes is cited in the literature review and includes analysing navigational patterns using: navigational software, navigational strategies, tools to aid navigation, and indices. Horney's work can be regarded as a good, easily understandable introduction to the study of navigational patterns and this is fully explained in the literature review (detailed in 2.2, Chapter 2). Research on how users preferred to navigate by Simpson and McKnight (1990) looked at different structures in a hypertext system. They varied the structures and cues for the subjects from alphabetical indexing to hierarchical structuring, using typographical cues and giving provisions for position indicators. Their results showed users had preferences for hierarchical navigation patterns.

Henderson (1993) identified two conflicting viewpoints when she argued that the prevalent characteristic of the modern worldview was the dependence on the conceptual view of information as being hierarchical, which conflicted with that of time, which produced a linear and sequential pattern. It is this dichotomy that Henderson considered made the investigation of multimedia more difficult, as users wanted to use the resource hierarchically, but moved through it sequentially. Finally in considering user's issues, Romiszowski (1990) argued that a 'click where you want to go' system would give optimal control to the user but he stated that the user employing this system must be aware of what options were available. This awareness of the options available was a critical element of the user issues and created a link with the designer and pedagogic issues. The concept of the user having their own individual program or a more specific person-orientated program is feasible with multimedia, and if users have preferred methods of navigating this would promote better methods of exploiting multimedia. Therefore research investigating the navigational patterns and working strategies each user prefers to employ and the variations in choice, would enable multimedia designers to create better, well-adapted and more enjoyable multimedia.

1.4 The designer's perspective

Yildiz and Atkins (1993) criticised multimedia products as, despite the technical potential of multimedia, and the multimedia facility of allowing various modes of user interaction, designers were still failing to create courseware that matched our current understanding of how human beings learn effectively. Although this immense potential for multimedia made educators keen to use the new technology, they needed convincing evidence of the claimed instructional effectiveness of multimedia, as many studies failed to show the effectiveness of multimedia in terms of the amount people learnt from it, and these studies have been severely criticised for this failure. Designers are still not creating products that fully exploit both the technical potential of multimedia and the opportunities for user interaction. Parunak (1989) has produced a classification of methods that could be used for navigation and proposed that these elements could be incorporated into multimedia software design. However his work was theoretically based and needed further empirical investigation. Trumbull, Gay and Mazur (1992) viewed multimedia design in terms of the tools employed, their navigational and guidance potential, and how individuals used them.

This provided a suitable approach for further studies of navigational methods. Fitter (1979) proposed that the user needed to have an adequate knowledge of the system in order to make effective use of the software. This meant he needed to know i) where he had been, ii) where he was, and iii) where he could go. Users clearly need to be aware of at least the basic structure and contents of the software resource, before being able to develop awareness and knowledge of the best methods of navigating it. The question that needed to be resolved for designers was how the user's requirements could be best integrated into the design of educational multimedia. Developing good software design and content that allowed a user preference approach was potentially possible in multimedia. Analysing users' navigational paths, creating flexibility in software design and investigating user's navigation patterns and working strategies preferences, would signal a shift by the software designer towards meeting end user requirements that would inform and improve multimedia design.

1.5 The pedagogic perspective

After summarising the research in this area I proposed (Fenley 1997) that users needed to:

1. Have some knowledge and awareness of navigation before they started using a package;
2. Be taught how to use it successfully and;
3. Be encouraged to develop their own skills and abilities in using the software.

These issues demonstrate the importance of the individual; in terms of the skills and abilities they start with, and their development of an awareness of their navigation and working preferences.
It also shows links between the pedagogic and user perspectives. Self (1995) supported this view of the individual with his comment:

> Developers of multimedia learning systems are realising that presentation needs to be adapted for individual learners (p50).

The importance of the individual is a key element in this thesis. Kommers (1993) similarly asserted that the instructor should be prepared to define clear learning goals and minimum requirements for the user before he or she started using multimedia. He concluded that the development of hypermedia would require new scenarios for co-operation between authors, publishers, electronic and software companies.

1.6 The human computer interaction perspective

The human computer interaction (HCI) perspective relates the two components of designer and user: 1) how the user is made aware of the designer's viewpoint and 2) how the designer envisaged the package being navigated and used by the user. Landow (1990) was critical of the current state of research. He proposed that since Conklin's (1987) 'lost in hyperspace' viewpoint there had been more research on designing the interface for supporting orientation and navigation. Conklin's statement referred to the user becoming completely lost and disorientated while using hypermedia and not being able to orientate themselves as to their position in the resource. Conklin's seminal work on hypertext is frequently referenced in the literature. However Landow was critical of these approaches as they misled users by allowing them to think it was possible to construct an adequate mental model representing the structural and functional features of hypertext. Landow considered that navigation could be described as the art of controlling the course of a plane or a ship, but that this presupposed that the user was in a spatial world, which he thought impossible, as hypertext was not experienced as a spatial world.

This was an area where there were significant differences between hypermedia and multimedia, as although the content of each medium could be similar, their methods of use and structure were different. Multimedia allowed much more freedom of movement and navigation than hypertext, which was often used in a purely sequential way. Multimedia was experienced as a spatial world and because of this the user needed excellent navigation facilities in order to understand the three dimensional world. Although hypermedia did provide hot text links and an ability to jump to associated areas or stacks, multimedia had greater variety in how these links were made and in the possible user directions. Although users may become lost in hyperspace, it was less likely in multimedia, as there were more options for recovering one's position and relating oneself within spatial multimedia. Developing helpful, informed navigation methods in multimedia spatial worlds is an underlying theme of this thesis.

1.7 Working Strategies

This thesis assesses whether there are differences between how the user physically navigates through multimedia, (the navigational patterns), and the mental methods they employ while doing this (working strategies). Navigation in multimedia is usually considered as a metaphor, i.e. the mouse/ keyboard is used to move around a virtual space. It is important to differentiate between the methods the user employs to move and the thought processes used to work through the multimedia package. This need to recognise the physical or geographical movement through the resource is termed the navigation patterns in this thesis, although this reflects a way of representing connections in the underlying medium rather than true physical movement. The mental processes (the antonym of physical) are referred to as the working strategies. The selected working strategies research investigates individual differences, as well as the need for the individual to be responsible for, and in control of, how they work. Despite similarities in approach to interpreting navigational patterns and working strategies, several researchers (such as Parunak, 1989 and Canter et al., 1985) highlight the dichotomy between them, and the fact that they were distinct processes. The literature working strategies review outlines Trumbull, Gay and Mazur's research (1992) on the techniques and strategies employed.

Brooks, Simutis and O'Neil (1985) describe categories of individual differences (abilities, cognitive style, prior knowledge and motivation), which are relevant to working strategies and deserve further elaboration and discussion.

1.8 Summary of the research approach

In summary the main research and subsidiary/related questions for this thesis are given below:

Do individuals have distinct preferences for certain types of navigational patterns?

- How are these preferences affected by system and navigation design?
- Are these preferences related to the user's approach to software and their working strategies?
- Are there differences in group preferences e.g. children vs. adults, novices vs. experts?

The focus of the research was therefore to discover the preferences users had for navigational patterns and the variation of these pattern types between groups of users, and to determine what underlying fundamental issues in establishing patterns and preferences will advance understanding for all perspectives. It was valuable to see if all the members in a specific group used these individual user preferences (by investigating the group's range of variation). The user and designer perspectives were considered with the navigational patterns to determine the effect these preferences have on the system and possible navigation methods, while the user's working strategy preferences were assessed in relation to the navigational patterns. The effects of the pedagogic and HCI perspectives were also explored and the links between all four perspectives create a multifaceted approach to the study.
The empirical work concentrated on the two specific delimited areas of 1) children to adults and 2) novices to experts. McKnight, Dillon and Richardson (1993) looked at navigation through complex information spaces and the need for cognitive maps and ways to develop them, and commented on issues, which were very relevant to this research:

> The expression of navigation difficulties is rarely supported with clear evidence however, and the need for sound empirical work here should not be underestimated...With respect to navigation of semantic space, it seems that existing research has little to tell us and the onus is on workers in the area to gain an understanding of such concepts through their own work (p.86).

1.9 Conclusions

This research has sought to fill the gap in knowledge of navigation by explaining which patterns users preferred, which patterns and strategies best supported the user's goals, the ways in which these were perturbed by ill considered system design and the range of variations in these choices. If the navigational patterns were apparent and it was feasible for designers to inform design with this knowledge, this should result in better software. Looking at the issues from four perspectives should enable both a more balanced or measured approach even moving towards an investigative approach, which looks at these issues and their affordances.

If the software is designed to enable better ways of approaching the subject (designer), users should be able to focus on substantive learning (user/pedagogy) rather than navigating the system (HCI). Finding information out on how the user wants to use the system and how they prefer to navigate, provide information for the designer to use when determining the structure and the best methods of use of the software. Information from the pedagogy field would allow designers and users to make the best use of the resource and to match their usage with both their own preferences and those of a tutor or expert who has tried out the package before, and this in turn creates the need for an intelligent tutor. The intelligent tutor could be programmed with the user's preferences and the package structure as well as the pedagogic aims and tasks, to provide the best help and guidance for the individual.

The HCI perspectives could allow designers to create unobtrusive and easy to use software for a range of users with different skills and abilities. This links in well with the human computer interface research which has promoted O'Malley's view that the interface should be transparent to the user, i.e. they should not even be aware that they were using one to access the software (O'Malley, 1989) and Mayes (1988) who asserted that the interface needs to be cognitively invisible. In order to create flexible and innovative software all these perspectives need to be taken into account to create good educational and commercially viable products.

In order to assess the navigational patterns and working strategies that users have, empirical studies were a crucial part of the research. The empirical work was developed by looking firstly at children and their use of multimedia (the first study) and secondly at adult's use of multimedia (the second study). This was to investigate the navigational patterns of each group with similar tasks and to cover possible choices with the two groups, children/adults and novice/expert.

The potential benefits of multimedia, which allowed users control over their own learning environments and to achieve their own goals, are immense. The value of researching multimedia, and developing these facilities was to establish whether this potential could be realised. The analysis in the literature review of the different methods used by researchers in the navigational patterns field and their findings has highlighted some of the major issues and the areas that are most in need of further empirical work. The outcomes from this research are expected to address these issues, but the main focus of this thesis is upon the relationship between the user and designer perspectives. Beasley and Vila (1992) have stated the following with regard to research on users access in multimedia:

> Although many have put forth theories and innovations for helping users navigate through large databases of information more efficiently, little research has actually examined the methods of access that users desire to employ when accessing large amounts of information in a multimedia environment (p.222).

User's navigational patterns and individual preferences are essential elements that need investigation, and the available literature indicates that there are many reasons for an individual's choices, and the key question that has not been investigated is how these are identified and assessed.

1.10 Explanation of terms

The terms used in this thesis require explanation and are detailed in the glossary at the beginning of the thesis. The terms 'expert' and 'novice' indicated the user's experience and present level of computer skills. Researchers have used several different terms such as learning, working and reading strategies, but these have been differently interpreted, the term working strategies was used purely to describe the mental processes users employed to work through multimedia software. Similarly the term 'preference' was used to determine the individual's choices.

1.11 Thesis Outline

The thesis is divided into an introductory chapter (Chapter 1- this chapter) and five parts, these are:

Part I: The literature Review - Chapters 2-6, the four perspectives

Chapter 2: User's perspective - User issues are assessed such as how the user navigated through the software, with Horney's work (1993) being key to this perspective.

Chapter 3: Designer's perspective - The designer issues literature is detailed, with a focus on researchers such as Parunak (1989), who classified navigation paths and Trumbull, Gay and Mazur (1992), who used in-built tools to determine navigational patterns.

Chapter 4: Working strategies - Research on working strategies is outlined.

Chapter 5: Pedagogic and HCI perspectives - Outlines are given of the pedagogic perspective (expert to novice divisions and recall), and the human computer interface perspective.

Chapter 6: Integrative summary and statement of thesis aims - The chapter's purpose was to investigate the users navigational patterns and working strategies from other researchers.

Part II: Methodology and Software - Chapters 7-8

Chapter 7: The methods - The research structure and the two studies are described with the purpose of outlining the research methods. These were influenced by Suchman's (1987) plans and situated actions. The criteria and decisions on the participants and software were explained. Suitable tasks, (e.g. McKerlie and Preece (1992)) were outlined, before the final tasks were chosen.

Chapter 8: Software - Chapter 8 describes the software used to compare navigational preferences.

Part III: First empirical study - Chapters 9-12

Chapter 9: Results - Chapter 9 outlines the results from the first study, which investigated children's navigational preferences in multimedia use in two Oxfordshire schools.

Chapter 10: Navigation patterns - The navigational pattern's chapter discusses the first study empirical work. Navigation patterns from Horney, Parunak, and Canter et al. are described. The chapter's purpose is to detail, classify and empirically test the navigational patterns.

Chapter 11: Working Strategies - Chapter 11 reviews the second main theme of this research - the working strategies, classified by various authors as reading or learning strategies. The working strategies from the first study are analysed and a classification produced.

Chapter 12: Lessons from Study 1 - Chapter 12 discusses the links between the navigational patterns and the working strategies recognised in the first study. The purpose of this chapter is to analyse this relationship and links, and define how these will be further empirically tested.

Part IV: Second empirical Study - Chapters 13-17

Chapter 13: Methods - Chapter 13 covers the second empirical study completed for this research. This summarises the first study, and discusses possible work within time limits. The second study methodology is outlined, followed by the tasks and the software to be used. Each multimedia session is explained and the methods for observing and recording the users.

Chapter 14: Results - Chapter 14 records the results of the second study. A chart of each individual's navigational routes through the software is developed for each user. The analysis of each individual task is included together with comments on the search methods.

Chapter 15: Navigation Patterns - This details the analysis and discussion of the navigational patterns used. The second study was designed to test the navigational patterns from the first study, to see if adults also have preferences, and if they have the same or a larger range of patterns.

Chapter 16: Working strategies - The second study analyses user's preferred working strategies.

Chapter 17: Lessons from Study II - The discussion chapter relates the two studies and analyses the patterns and strategies, and compares these for the children/adult and novice vs. expert groups.

Part V: Conclusions - Chapters 18-20

The conclusions discuss the research achievements and its contribution to multimedia research.

Chapter 18: Summary of the Key Findings - This summarises the key findings and their significance in relation to the four perspectives, designer, user, pedagogy and HCI. Evidence is outlined for the navigation patterns and the working strategies and for the different user groups.

Chapter 19: Implications for practice - Recommendations for future practice and multimedia design are stated, with the model for analysing navigational patterns and working strategies

Chapter 20: Evaluation, and users and future research implications – The purpose of the chapter is to summarise the research findings, thesis achievements, limitations and future potential research.

Part I Literature Review

Part 1 Literature Review

Chapters included in Part 1:

Preface - Background to the literature review

The rationale for the research focus on navigational patterns was the need for research in how users employ or use multimedia and how this differs from the structures developed by designers to enable navigation through the software. Issues such as the pedagogic concerns with how users are using the software and the HCI issues on how the software could be improved to facilitate use, are also integral to the study. The need to match user and developer concepts of the software design is paramount. Using navigational patterns is a way of both determining individual/pairs use of the package and possible routes through it, and of comparing different users through the same or similar software. Finding out if there are different methods of navigating or different tools or facilities that the user would prefer to use is also important in this respect, and one of the potential outcomes of the research would be to give examples of available tools that could be designed into the software, so that each individual could maximise both their use and the benefit gained from using the software.

The final part of the thesis gathers together the evidence for the use of different tools and proposes a series of tools that would both aid navigation and the understanding and use of the software. These tools cover all four of the perspectives and so provide a practical way of developing user centred software which is flexible for each individual and which builds into the software the different elements of the designer and user views, and the best pedagogic and HCI design principles. The dichotomy between the user and designer is a difficult one to decipher and the concentration of this thesis on navigation patterns was to determine the nature of these differences and similarities in approach. After the initial search for information another element emerged, as not only were the physical methods of navigation important but also the mental processes of navigation – the working strategies.

The literature review starts with the user issues, continues with the designer issues, deals rather more briefly with the pedagogy and HCI elements (as these have been less researched and some of the decisions on these areas need further empirical work) and finally covers the working strategy research. The final chapter (Chapter 6) in Part 1 synthesises this approach and provides a framework for the research work.

2

User Issues

2.1 Introduction to User issues

The literature review describes and analyses research on navigational patterns and working strategies in interactive multimedia. Reed, Ayersman and Liu (1996) have noted the lack of research on navigation in general. Several of the research projects discussed in this chapter relate to hypermedia but these cited examples were relevant to multimedia. In the introduction different approaches to analysing software have been considered, but the concentration on users and designers, e.g. how similar the user's approach and what was intended by the designer are, has focused on the need to find a way of examining these differences. Navigational patterns allow individuals and pairs to demonstrate how they use the package and the facility to navigate within the package is controlled by the designer. I felt that looking at navigational patterns would enable me to examine the different approaches of designer and user and be able to demonstrate this, and use the patterns to compare users.

The first perspective discussed in relation to navigation patterns is the user perspective. The user's perspective is discussed in two sections; the first investigated recording software for analysing navigational routes and the second the use of indices to determine user's navigation preferences. The research outcomes in this perspective were expected to lead to proposals for improvements in how multimedia software could be designed to meet user requirements. Research on the user perspective involved: observing users and investigating each individual user's chosen navigational patterns using a range of methods which consisted of: 1) navigational software, 2) navigational strategies, 3) tools to aid navigation, and 4) indices (cf. summary table 2.1 overleaf). The research cited in Chapter 2 is listed below:

User perspective Research	Research authors	Location
1) Audit Trail usage	Horney 1993	Section 1, 2.2
2) Users log files	Lawless and Kulikowich 1996	Section 1, 2.3
3) Audit trail Software	Beasley and Vila 1992	Section 1, 2.4
4) Indices	Canter, River and Storrs 1985	Section 2, 2.5
5) Different Interfaces	Canter, Powell, Wishart & Roderick 1986	Section 2, 2.6

Research undertaken by Horney (1993), and Canter, River and Storrs (1985), both recorded and discussed the navigational paths of individual users. Horney and Canter et al.'s projects were very appropriate for this thesis, and form the basis of the navigational patterns research from the users perspective.

Research by Simpson and McKnight (1990) on how users preferred to navigate looked at different structures within a hypertext system. They varied the structures and cues for the subjects from alphabetical indexing to hierarchical structuring, using typographical cues and giving provision for position indicators. Their results showed users had preferences for hierarchies. When researching different navigation methods, Henderson (1993) commented that the prevalent characteristic of the modern worldview was the dependence on the conceptual view of information as being hierarchical, and that this conflicted with an alternative conceptual view, that of time, which produced a linear and sequential pattern. It was this dichotomy that Henderson considered made the investigation of multimedia packages more difficult, as users wanted to use the resource hierarchically, but moved through it sequentially. The user's perspective and gradual acquisition of navigational skills and awareness were emphasised by McKnight, Dillon and Richardson (1990):

> Acquisition of navigational knowledge proceeds through several development phases from the initial identification of landmarks in the environment to a fully formed mental map (p.69).

The concept of a mental map related navigation patterns to the mental processes involved in working through software, and with physical awareness of where the user was in the package. Shum (1990), discussing navigating in multimedia and the user's acquisition of spatial knowledge as a two-step process, produced similar results to Simpson and McKnight. Shum explained the first step as the acquisition of route knowledge, where the information was context dependent, and the second step as the acquisition of map knowledge, in which the individual understood the global spatial relationships, navigation was then world centred.

Section 1 User perspective - Audit trail usage

2.2 Using navigational recording software for user's trails

Horney (1993) investigated hypertext by looking at the user's experiences and describing the navigational patterns that emerged. Horney referred to users by the term readers and to software designers or hypertext authors by the term author, although he also referred to hypertext authors as users. These authors were creating hypertext and were experts or competent users of the system, but Horney investigated how they used the software and the patterns these experts had chosen to use. Horney's research was one of the most valuable research projects for this thesis as he observed users and then created a series of navigational patterns related to these users. His work mitigated the lack of research on differences in novice and expert behaviour in multimedia and methods of analysing these, as he used experts but defined a very specific method of tracking users, which could be used in further research. One of the problems of his research was that he only used eight hypertext authors or experts which meant that there was a need to expand this user base to see if his sequence of navigational patterns could be applied over a wider skill and ability range. Horney discussed the relationship between these patterns and effective hypertext use. His subsequent work looked at how users worked through software, which is discussed later under working strategies. Horney employed a software program that allowed each user's exact route to be recorded.

This program, called EntryWay[1], had two special linking features - standard binary links and threads, which could be used to link themes or groups of nodes. This gave the user flexibility in the ways users negotiated the nodes. EntryWay navigation allowed four different techniques:

1) Document links - using the Thread, Links and Members menus allowed standard hypertext linking and document links. Pull-down menus accessed the first threads/ binary links/ current node.
2) Thread traversal - visit all the thread's members (used for themes or a group of nodes), by activating a particular thread and using Next, Previous and Go commands. A pointer allowed thread traverses, or the navigation of nodes not on this thread, and a return was available.
3) HyperCard functions - such as First, Next, Previous and Last, which were used to move along the stack in the physical linear order of the nodes.
4) Select and Go technique - as each node had a unique name the user could go directly to it, or use the Selection option, and it could be revisited by reselecting it from the Trail menu.

This last technique (Select and Go) was the most powerful one, as authors could traverse from any node to any other node, regardless of any other formal relationship among nodes created by threads and links. In Entry Way each node was explicitly linked to each other. EntryWay maintained a history of the visits to each node, through the Go menu. This allowed access for the researchers to record where the date, time, and method of traversal were recorded for each visit into a node history. These histories indicated each reader's navigational pattern and it was these histories of eight experienced hypertext users that Horney analysed. All eight subjects used EntryWay for their own data collection or research, 1) for mathematics tutor's interviews about long-range goals and objectives in mathematics education, 2) an ethnographic study of a teacher educator, 3) the presentation and questioning techniques of math teachers 4) to collect and analyse laser disk images 5) to create presentations of Chinese poetry, and three subjects created dissertation bibliographies. Using EntryWay for specific tasks in the subject's own work was significant, as this allowed them to computerise and facilitate their work, making their tasks more manageable and productive for the user. By analysing the user histories, Horney identified five navigational patterns, Linear Traversal, Side Trip, Star, Extended Star and Chaotic (cf. Fig 2.1, overleaf):

1. Linear Traversal: this was moving in a linear pattern from node to node, user-visited nodes in their physical order

2. Side Trip: (a variation of Linear Traversal) this was mainly linear, but with visits to other nodes not on the main path. The use of this pattern was more common than that of Linear Traversal.

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[1] EntryWay was a hypertext authoring extension for *Hypercard.* EntryWay provided for nodes, links and active navigation by readers and recorded each user's trail through a particular piece of software. EntryWay used Threads to link associated nodes and allowed flexibility in traversing the nodes. The system provided a graphical history of each user's path, together with grouped nodes or topics.

3. Star pattern: the user moved from a central node, often called the root node, and returned to this, also seen in map-making activities.

4. Extended star: this was the same as the star pattern, but could incorporate revisiting nodes, primarily through the use of out and back cycles

5. Chaotic: had many different traversal methods and moved through a document at random.

Horney stated that the Linear Traversal pattern was the simplest pattern recognised. The Side Trip pattern was described as a variation of the linear traversal one, as it used the same basic linear pattern as the linear traversal but the user made visits to nodes off their main path. The Star pattern was a basic linear traversal, but became a star after the next step, i.e. a return to centre. The essential distinction was that the route changed and allowed the pattern to be re-classified.

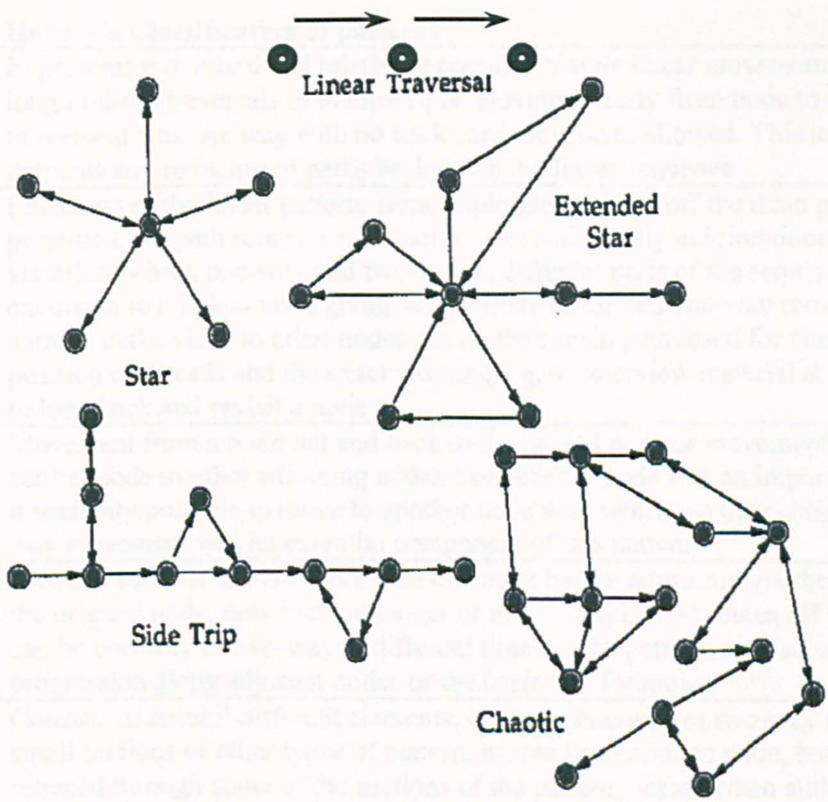


Fig 2.1 Navigational paths from a navigational report package (after Horney)

The Chaotic pattern represents a random movement through a document, a mixture of patterns or the lack of any specific pattern. Horney did not believe that his Chaotic pattern users were lost, as the users had few significant difficulties in finding their route from place to place. Horney argued that these user's patterns could have been too complex for any more regular pattern to be discernible, and that the Chaotic pattern could be the result of a mixture of other patterns. He extended this concept of the Chaotic as a mixture of patterns by considering that this mixture concept had the potential of being partially true for all the patterns. Few of these occurred in a pure form but they could be mixed together as the needs of the authors or users changed through time. He stated the Chaotic pattern was a result of complex goals being sought by experienced authors:

> Reader navigation is constrained by the prior decisions of authors who force readers into particular styles of navigation….software design that incorporates set or explicit routes and therefore less choice, restricts the navigational preferences of the user (p.267).

Horney's two linear patterns were frequently used with the Next commands, which moved the users along threads or through Hypercard stacks. The Star pattern users chose Selection followed by the EntryWay command, or Trail to return to the Star's central node (i.e. retracing the user's route back). The Chaotic pattern users employed specific mechanisms (Selection and Input), which allowed navigation outside regular links. Horney outlined his pattern's shapes but did not give any details, e.g. giving each pattern exact delimiters. Fig 2.2 outlines each pattern based on Horney's description. He stated that the Linear Side Trip was a variation of the Linear Traversal.

	Horney's Classification of patterns
Linear	Represents a standard and relatively common simple linear movement. Examples - long in-order traversals of manuscripts, moving linearly from node to node, movement was one way with no backward movement allowed. This movement prevents any retracing of paths back down the linear sequence
Side Trip	Extension of the linear pattern, some exploratory routes off the main path were permitted, off path routes were usually short and usually unidirectional, some variations - both one-way and two-way at different parts of the sequence, can be excursion to a linked node giving an alternate linear and one-way route, used when authors make visits to other nodes not on their main path, used for checking the position of threads and the exact wording e.g. of interview material & could be used to loop back and revisit a node
Star	Movement from a node out and back to the central node or movement from this central node to other adjoining nodes from central node was an important attribute as it was only possible to move to another node with return via the central node. Two way movement was an essential component of this pattern
Extended star	Allowed the user to visit more than one node before returning, via the second node to the original node, may include longer or more complicated routes off the basic route, can be one-way or two-way at different times of the pattern, can include some linear progression along adjacent nodes or the basic star formation
Chaotic	Consists of several different elements, could be one-way or two-way and represent small sections of other types of pattern, moves from node to node, but paths could be retraced through some of the sections of the pattern, occurs when authors use multiple traversal methods and move randomly through documents

Fig 2.2 Description of navigational paths (adapted from Horney)

He then commented that the Linear Side Trip was more common. This implied having one basic linear category with some variations. The differences shown, although significant for mathematical graphs, were less distinguishable with multimedia, where the exact node positions were less distinct. Direction and movement from node to node, although easier to recognise, was less effective as a distinction, as both methods were essentially linear. As users' behaviour fluctuated between the two modes (linear side trip and linear traversal), it would have been more sensible to define one linear pattern, with variants. Horney did not elaborate sufficiently on the Star pattern to make it easily recognisable by other researchers. However Horney's classification relied on the user repeatedly returning to the original node. Hence although the Star pattern may have had some linear progression in Horney's classification, the essential attribute for his classification was this reliance on the central node. Horney's star pattern was detailed as two-way, but with each visit to each node in the star returning to the central node. This meant that the central node was revisited often and that each of the other nodes must lead off from there, rather than from adjoining nodes. However this Star pattern, with the prescribed necessity of returns to the central node before moving to the next node, was a difficult one to visualise in a multimedia context. Although a Star pattern may well exist in navigation this use of the central node was less likely, as it implied both a very limited and restricted structure, and the use of a central node structure is not a practicable structure for multimedia. The Star pattern was more likely to be used to frequently move down a level in the software and return to the original level, this represented a sampling type of pattern, allowing the user to investigate the next level down in the resource.

The Star pattern was more easily recognised where there was a change of level. The exact parameters of the Extended Star were also not clearly stated or defined. The Extended Star pattern could be easily distinguished from the linear routes if it crosses more than one level downward in the resource, rather than on the same level (although this would also be a possible pattern). It was not clear what Horney's version does from his description, as it may include longer or more complicated routes off the basic route. There were some difficulties in interpreting these patterns, as it was not always clear whether or not they were one way or bi-directional. It was not clear if the patterns, e.g. the Star, had to be complete, or whether a partial section of a pattern was sufficient for Horney's classification. For example there was little difference between the Linear Side Trip pattern and some linear sections of the Extended Star, if the star was not completed. Therefore it would have been necessary for the user to complete the pattern, in order for it to be recognised as an Extended Star. This may not always happen in multimedia usage. It was difficult to determine if the user's pattern was purely linear, and it would have been better to list the requisite components for a complete star or circle.

The Chaotic pattern definition represented the case where no identified patterns could be observed. However elements of other patterns could be recognised within the Chaotic pattern diagram. The Chaotic pattern may have acted as an umbrella or general category, supporting the theory that the Chaotic pattern was a mixture of other patterns. The implication is that there was a need for a further sub-division of patterns, i.e. as there were only a few patterns in Horney's scheme, it followed that everything else got placed in a general category, which in Horney's series was the Chaotic one. However when experts were using software they frequently moved through the software very fast, and this rapid rate made discernment of specific patterns difficult. In addition the expert frequently changed direction or research method and this resulted in a short usage sequence of each pattern and rapid changeover. The lack of exact definition of Horney's patterns raised the questions: Is any excursion off the linear route allowable when identifying the pattern type? Does the user have to return to the same node? Or could they continue if route is linear?

This issue of completeness raised other questions: did the degree of complexity of pattern indicate that the user was experienced (i.e. the more complex the pattern, the more experienced the user) or does this simply signify that they were more capable of using the resource? In what way does the navigational pattern intersect with expertise and skill? If the patterns were not in a pure form, i.e. they were fairly complex; the most significant pattern(s) for each individual user would be those that they use most, which supports the concept of a dominant pattern or pattern group for each user. These questions will be addressed by this research and they should be answered to some degree by a more detailed and defined classification of patterns. Horney's research partially supported this concept of a classification as he produced a range of navigation types, which could be examined and applied to an individual user's routes. The exact nature of each type was still problematic, as the types were not specified formally. The categorisation of the patterns was not sufficiently rigorous for these patterns to be easily determined or allocated by other researchers, and hence there was a need for a more systematic and comprehensive classification. Horney's research related the use of specific navigation patterns with the use of specific commands or types of action. The relationships Horney discussed between the patterns used and the working strategies users employ is discussed later (4.4). Horney's research investigated expert's navigation patterns and an outstanding literature gap related to the navigation differences between novices and experts.

2.3 Using log files

Lawless and Kulikowich (1996) recorded user's log files in their work on user's navigational routes. They used cluster analysis, rather than Horney's method of comparing nodes visited and the duration of the visit, to see if there were any similar patterns. They found three navigational performance patterns: Knowledge seekers, Feature explorers and Apathetic hypertext users. They thought that the ability to look at individual differences without obtruding on the individual's use of the computer was very constructive. However as their patterns were more reflective of the types of users rather than their navigation methods, they have not been detailed at this stage. They were also interested in interfacing with individual computer users. An ethnographic approach to observing and analysing user's routes through software has been shown to be constructive, and could be used as an informative method for empirical work in navigational patterns. The concept that individual users may have their own specific preferences for navigation needs further testing.

2.4 Using audit trail software

Beasley and Vila (1992) researched the use of paths through time, and concentrated on transitions between screens. They were interested in firstly identifying any prominent patterns of access in terms of linearity or non-linearity, and secondly in examining the relationship between these patterns of access and learner aptitude. The first aspect of their research, the division of patterns into linear and non-linear related to how linear the user's movements were, or if they had totally linear as opposed to non-linear (i.e. hierarchical) patterns. The second relationship that they wanted to investigate was measured by specific tests measuring student's aptitude called ACT tests, which were given in different subjects. Beasley and Vila believed that the ACT English scores were the best predictors of linearity or non-linearity for the users. They proposed that lower ability users took a non-linear or exploratory route for navigation purposes compared to the higher and middle ability users who tended to be more linear. The instructional model that Beasley and Vila built consisted of a resource in two formats, linear and hierarchical, allowing the user to navigate in either a textbook (linear) manner or a more exploratory (hierarchical) manner. Linearity was determined if the user followed a linear path, e.g. if they moved on to the next screen in the sequence. Non-linearity was determined when a user jumped to a screen out of sequence via a hot spot on the screen. Beasley and Vila's results demonstrated that most users employed a combination of both approaches. Davidson-Shivers, Shorter and Jordan (1999) though identified student's use of learning/ working strategies, together with their encoding processes and their navigational decisions while using a hypermedia course on propaganda. Their results showed a wide range of variation amongst the students (fifth grade level), with high test score students using more and more varied learning strategies as well as being more consistent in their navigation decisions than the other two (lower scoring) test groups. Although the low test scoring group used the encoding process more than the others, their construction contained more errors or was faulty.

Beasley and Vila's findings of two patterns, but in differing amounts, indicated that users had distinct preferences for certain patterns. However the basic dichotomy used in Beasley and Vila's research was too simplistic and a greater range of pattern types needed to be tested. Experiments with other potential pattern types, or with software that allowed a choice of patterns, was necessary if the hypothesis of users having distinct preferences was to be developed. The hypothesis proposed by Beasley and Vila was that lower ability users were non-linear and higher ability users were linear but this was difficult to support with the data they presented. Further analysis of their results revealed that this was only true for the lower ability female group, as males of higher ability use non-linear methods. Their initial premise was that females take a less exploratory approach than males. These potential differences emphasised that user's preferences do need to be examined to determine the patterns. This thesis will cover gaps such as preferences and open routes.

Section 2 - Navigational software using indices

2.5 Using Indices to determine navigation

After the work on navigational tools detailed above, the last major area for user issues in navigational patterns research was the use of indices to analyse each user's navigational patterns. In this area Canter, Rivers and Storrs (1985), investigated user navigation through interactive databases and developed a set of indices in order to characterise each user's search sequences. They proposed that these indices could be used for precisely defining search strategies such as browsing and scanning. They started with the premise that users were already aware of how to navigate through concrete environments, such as a city, and how to navigate through data. They argued that it was constructive to explore whether or not there was an analogy in the psychological processes involved in user navigational patterns. They considered several factors crucial to understanding user's navigation patterns; such as the task the user was performing (directly or indirectly affecting the path), and the user's preferred strategies. Canter et al. characterised the data structure not only by links within the components, but also by the control options available, and the constraints imposed by the task. They believed that it was too easy to state that all the users followed a certain path if that was one of the few available, as true options of choice and preference could only be recognised if there was free movement within the resource.

Canter et al. developed six indices to characterise user's navigational behaviour: Pathiness, Ringiness, Loopiness, Spikiness, NV/NT (ratio of Nodes visited/total nodes possible) and NV/NS (repeat visits to nodes/ total sampled by user). The latter index gave a significant measure of the redundancy of the data structure as well as an indication of the student's navigational method. They used the HAIR (Human Aspects of Information Retrieval) programs to interpret the user's routes. Differences in navigation were looked at through the constraints imposed by the software. In order to use these indices they first programmed a random user (a computer) and then observed a natural user (human being) using the software, with two different front ends, 1) a menu and 2) a command format. The menu front end gave the user a choice of eight options at each node, each option being a path to another node. The command front end allowed the user to move to any node in the system, but the user could also list all nodes connected to the present node. Each of the two front ends gave the user the same sign-posting information, but differed in the navigation control through the data. The interaction between the user preferences and the effect of software limitations were investigated. The user tasks involved 1) locating and adding database references and 2) adding links between nodes.

Random user results (the computer) – The random user visited fewer different nodes in the menu front end, than with the command front end. The computer had ten runs through the system with 150 simulated choices per run. The menu interface may have constrained a random user's navigation and this resulted in fewer node visits. In the random user only rings, spikes and NV/NS were statistically significant. The random user results were compared to the natural user results, which were less susceptible to constraints.
Natural user results (human) – The difference in spikeness was less pronounced between the two front ends, with a tendency to retrace a route in the menu condition, and a tendency to return to base by the user being more obvious in the command system. The natural user sampled more nodes in the menu condition than the random user (computer), but less in the command condition.

The number of runs and the time allowed for the natural users were not specified, but as the two users (computer and natural- human user) were compared they should have had similar or the same setups. They stated that the natural users could offset some of the constraints of the system, but they did not take as full advantage of the freedom with the command system as the random user.

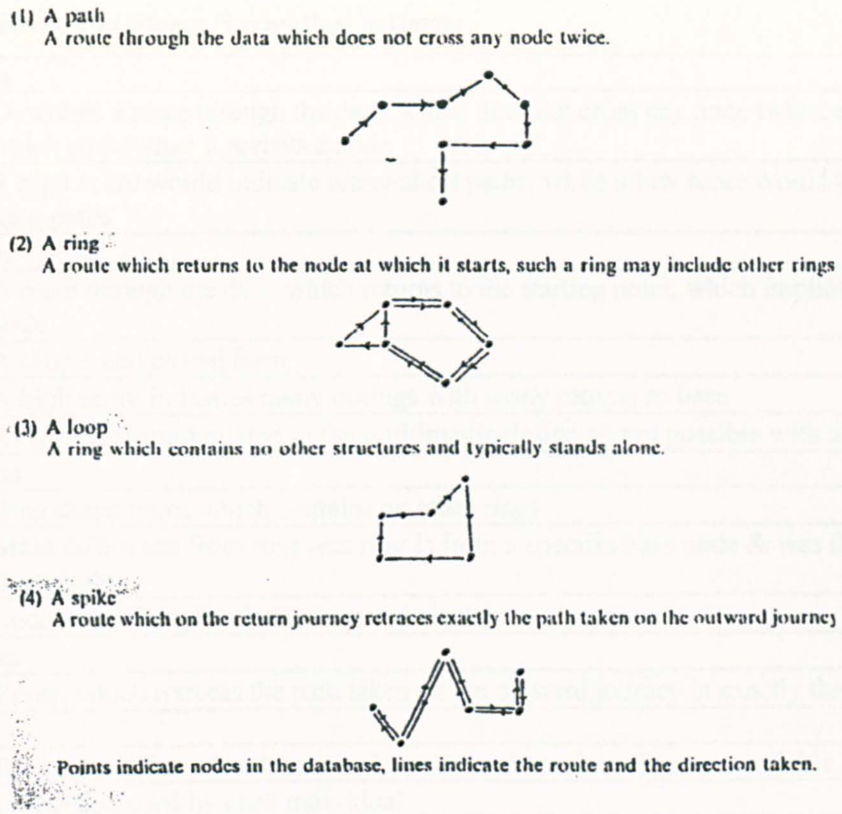


Fig 2.3 Representation of Canter, Rivers and Storrs' paths (after Canter et al., 1985)

This indicated that the navigation patterns followed were a result of poor software design and a true spikeness route/pattern would not normally exist. The NV/NS ratio was an effective indicator of how much of the resource was used, although it was subjective and inextricably connected with the task. Noticeable differences occurred between the two systems in terms of the navigational style the users chose. With the path pattern, the higher score in the menu interface indicated many short paths compared to fewer, longer paths in the command system. For the ring pattern, the menu condition encouraged more node revisits. In the loop pattern longer traversals were apparent which allowed other features such as small spikes to occur. The spike score showed a large number of spikes in the menu option, compared to very few in the command option. Users had recognisable patterns and the research showed some of the problems of pattern recognition by the users. Canter et al.'s navigational patterns are detailed in Fig 2.3, which has been developed from their explanations of each of their pattern types. The patterns are described further in Fig. 2.4 (overleaf). Canter et al. recognised that there were problems of overlap of some indices and that these may not have been sufficiently complex to cover the whole range of navigational behaviour. They proposed a system of identifying landmarks for frequently visited nodes, as an aid to navigating, and for orientation, and this concept of landmarks was crucial in later research by Canter, Powell, Wishart and Roderick (1986). The indices research showed that indices could be used to differentiate navigational patterns, but as these classifications also relate well to pattern types, it was difficult to distinguish between indices and set pattern types. Whalley (1990) looked at the problems of navigating and orientation within hypertext.

Canter, River and Storrs Navigation patterns
Pathiness
• Describes a route through the data, which does not cross any node twice, e.g. an exploration which stops when it revisits a node
• A high score would indicate many short paths, while a low score would indicate fewer, long paths
Ringiness
• A route through the data, which returns to the starting point, which implies a base/ starting node
• A simple and closed form
• A high score indicates many outings with many returns to base
• Ringiness feature related to the multimedia design so not possible with all multimedia
Loopiness
• Ring shape route, which contains no other rings
• Main difference from ring was ring is from a specific base node & was the only route from node
• Loops were simple, elementary and closed
Spikeness
• Route, which retraces the path taken on the outward journey in exactly the same way
NV/NT
• Ratio of number of nodes visited, to the total number of nodes available in the system
• Proportion used by each individual
• High NV/NT ratio indicates a more comprehensive search than a low one
• Ratio does not take into account the number of revisited nodes, therefore it may not be entirely accurate, needs further scrutiny of the audit trails
NV/NS
• Ratio of the number of different nodes visited to the total number of visits to nodes
• Resolves the problem of revisited nodes, measures redundancy of data structure & student's navigational method

Fig 2.4 Canter Rivers & Storrs navigational pattern components (Canter et al., 1985)

He proposed the creation of structures, which students should create for themselves as independent learners, but they might not be able to do this at first. He wanted to encourage the development of hypertext structures that were suited to browsing, but that facilitated and encouraged deep processing. Whalley believed that if designers were encouraged to design software with this facility the user's navigation would improve significantly. Observational studies should highlight the involving user facilities and the adoption of successful navigational strategies.

2.6 Using Different interfaces

Canter, Powell, Wishart and Roderick investigated user's navigational strategies and the navigation implications with different control options or front ends (direct addressing/linked addressing or directed addressing/parsed search). They looked at three different categories of front ends: command selection, menu selection and natural language techniques. They set up different user interfaces and were interested in the effect these interfaces had on the user's navigation. They used three conditions 1) command control – direct addressing, 2) menu selection – linked addressing and 3) natural language parsing – parsed search (moving from page to page entering words associated with the information), detailing condition's benefits/ disadvantages:

1. The command selection required knowledge of the commands, which was critical for experienced users as navigation was rapid with this knowledge, but difficult for novices.
2. The menu selection provided limited options for the user to select and was simple to use, but may have required navigating through several menus.
3. The natural language techniques allowed input of text commands, were simple to use and ideally suited to the novice user.

Canter, Powell, Wishart and Roderick's (1986) work on novice and expert users, which provided different interfaces to determine the user preferences was relevant here. They found three groups:

1) The first group answered a greater number of questions but spent less time on each, and they made the greatest total number of selections. A trial and error approach was used and ease of movement and confidence in navigating encouraged wider exploration.
2) In the second group members answered more questions than the third group, but fewer subjects than the first group, they used help and made more errors than the third group.
3) The third group accessed fewer pages, took longer over each question but made fewer errors.

Their results of Canter et al. showed the most successful navigational strategy was characterised by a high number of selections coupled with a relatively high error rate. Their pilot study showed that novice users preferred to be guided through a database by a series of linked pages and sign-posted options. Their multidimensional analysis separated out the three groups and provided what they considered clear evidence of differences in navigational strategy. Canter et al.'s work demonstrated that it was possible to analyse navigational paths in terms of the most successful path for completing specific tasks and they considered that using familiar concepts aided the exploration of an unfamiliar area. Canter et al. argued that research was needed:

> A novice database user is indeed a stranger in a strange land...what kind of transport system he needs and which navigational aids are likely to be the most help to him (p.257).

Ford and Chen's (2000) work on individual differences investigated the learning behaviour and performance of 65 postgraduate students using a hypermedia-based tutorial. Data on cognitive style, levels of prior experience, motivation, age, and gender was collected. Several statistically significant interactions were found. Field-dependent/independent cognitive styles were linked to strategic differences in navigation. Levels of prior experience were linked to quantitative differences in both navigation behaviour and learning performance. The findings from these research projects have highlighted the need for more novice and expert navigational patterns empirical research and on the most valuable tools for each group, which could be provided by the designer to aid this process. Canter et al. stated that front ends have considerable navigation effects but variables e.g. task environment, user motivation and individual differences need considering.

2.7 Conclusions on User Issues

The User Issues literature has investigated relevant research and highlighted gaps. Horney stated that tracking the users performing searches integral to their own work was significant, as there was a real need for the work and positive benefits from it. User's preferences could be constrained by the design of the system. Navigation options were needed as well as a comprehensive structuring of actual navigation patterns into a classification system. There was evidence on relating preferences for certain navigational routes with a student's ability, as well as prior knowledge, and computer skills. Certain strategies or navigation patterns were recognised as being more time consuming, but once a successful method of searching the resource was discovered the user often adopted this method to the exclusion of all others, even if the pattern was not the most suitable. Canter et al. (1985) noted that true options of choice and user preferences were only recognised if there was totally free movement within the resource. Researchers (such as those listed in Table 2.1) considered the software front end has a considerable effect on the user's navigation. Table 2.1 overleaf compares each of the research projects detailed in this chapter.

Table 2.1 Comparison of different research projects

User Issues Researcher	Project	Task	Outcomes	Navigation patterns	Main Features	Problems/ Future Work	What's Important	Gaps Noted	Significant For Thesis
1) Horney 1993	Navigational trails using Entry Way package No. of Users = 8	Individual projects for data analysis, bibliography creation, graphical & text	Paths for each user with times and record of nodes visited	Linear Traversal, Side Trip Star, Extended Star, Chaotic	Navigational paths link with way people work Differentiates navigational patterns & working strategies	Need more comprehensive breaking down of larger categories, more finite explanation/ differentiation e.g. one/two way problems	Creates types/ classification of routes and hypertext reading pattern list. Relevance of software to users own work - part of normal work = purpose to using it	Not v. comprehensive large chaotic category, no diff. between expert/ novice use, ethnographic recording use	Pattern classification Differences between Expert/ Novices
2) Beasley & Vila 1992	User's Paths looking at linearity and ability		Lower ability users preferred non-linear/ exploratory routes	Linear, Hierarchical	2 way division of users, definite preferences for patterns, links to abilities/skill	Definition of linearity, + 2 divisions, results unclear, need interpretation, linking linear/non linear/exploratory	Method of determining linearity, follow sequential course, if not or jump then non linear	Too simplistic, 2Way not helpful Definition - unclear what users researching or why	Links patterns to skills/ ability
3) Canter, Rivers & Storrs 1985	User navigation in interactive databases	Random user – computer & natural user, human users with two front ends, menu & command	Developed series of indices	Pathiness, Ringiness, Loopiness, Spikeness, NV/NT, NV/NS	Differences in navigation in terms of constraints imposed by software	Develop series of types of routes, valuable link between number of nodes visited and number of nodes available	Task users performing and users preferred strategies, compared users using the different interfaces	Incomplete range, no complete group or mixed routes	Indicators of individual students routes
4) Canter, Powell, Wishart & Roderick 1986	Different interfaces for subjects No of Users 10 Pilot 20 Main	Different front ends/ different conditions used to see the effect interfaces had on different subjects	Promoted the use of landmarks as familiar concepts to aid exploration of unfamiliar areas	Linked addressing, Parsed search A, Parsed search B	Different control options / front ends used, effect of interfaces on user navigation recorded	Different groups – differing amounts of time, instruction set knowledge valuable to navigate rapidly, successful search method reused	Navigation strategy successful in performance meant large number of selections but also high failure rate, novice/ expert differences	Task environment, user motivation and individual differences to consider in future – further empirical work	Front end considerable effect on navigation, effect of different interfaces, Individual differences

3

Designer's perspective

3.0 Introduction

The designer's perspective is divided into three sections; 1) using strategies and topologies; 2) using in-built tools for navigating and 3) using forced navigational paths. Tables comparing researchers, the project, users, tasks involved, and outcomes are at the end of the chapter.

3.1 Using Strategies and topologies

Navigational strategies and topologies have been used in multimedia to analyse the individual user's potential paths and there have been two main sets of research findings that have produced strategies or topologies. Parunak (1989) uses a theoretical approach to derive a working framework, while Trumbull, Gay and Mazur (1992) looked at the design of multimedia by reference to the tools users employed, the navigational and guidance potential of these tools, and how these tools were used. The researchers cited in Chapter 3 are given below:

Designers Perspective - Research	Authors	Location
1) Strategies and Topologies - Theory	Parunak 1989	Section 1, 3.2
2) Strategies – Empirical research	Wright and Likorish 1994	Section 1, 3.5
3) Specific tools	Oliver and Oliver 1996	Section 2, 3.7
4) Comparative usage different tools	Trumbull, Gay & Mazur 1992	Section 2, 3.8
5) Specific Tools	Allinson and Hammond 1989	Section 2, 3.11
6) Set Navigation Routes	Mischanuk and Schwier 1992	Section 3, 3.13

3.2 Theoretical perspective on strategies

Parunak described potential strategies and more relevantly, a series of topologies for hypermedia design. However his work was relevant to multimedia as many of the designer issues were shared between the two fields. Parunak's theoretical perspective was presented in three steps. Firstly he detailed a number of navigational strategies that users employ in physical (geographical) navigation. Secondly he related these to graph topologies, where he showed that restricting the connectivity of a hyperbase could improve the ability of users to navigate. Thirdly he analysed common methods of navigating within hypermedia in terms of both the navigational strategies and the graph topologies that users employed. Each of his strategies and typologies were approached from the system designer rather than the user perspective. Although Parunak details both 1) strategies and 2) topologies; he gives no examples of their actual use and has not supplemented his original theoretical work with any empirical testing. He commenced by identifying five common strategies from the geographical perspective: Identifier, Path, Direction, Distance, and Address. These strategies Parunak stated were the navigational strategies that humans developed to find their way around the world long before the advent of hypermedia. Parunak's strategies represented components of geographical routes rather than navigational patterns. Parunak's topologies were closer to, more representative of, and comparable to, navigational patterns used to navigate multimedia in the literature than were his strategies, and it was the topologies that were used here and compared to other researcher's navigation patterns. Parunak commented that a small number of alternate routes were easier to use than either a single route or a large number of routes. Although he emphasised that this was unsupported by experimental investigation, his argument was straightforward and persuasive. He believed that no choice limited the user and excessive choice confused or intimidated them, while some choice allowed some route selection.

3.3 Theoretical perspective on navigational topologies

Parunak, after describing his five basic navigation strategies, then developed seven topological structures, which linked to his strategies. These topologies were: - Linear, Ring, Hierarchy, Hypercube, Hypertorus, Directed Acyclic Graph (DAG) and Arbitrary. Parunak outlined a graphical representation of each of his topologies (Fig 3.1). Each topology's attributes are overleaf.

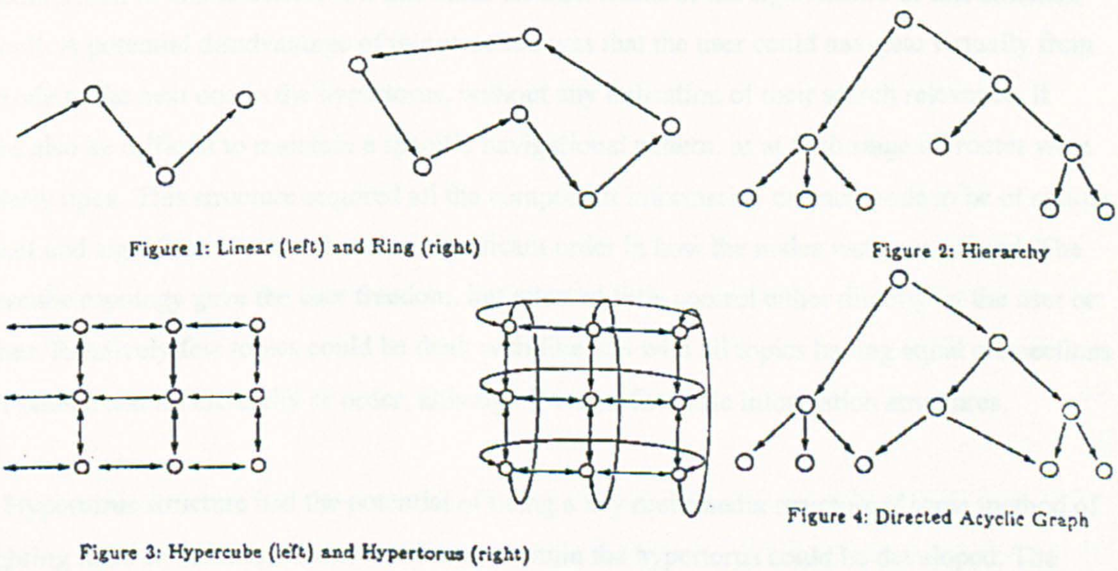


Fig 3.1 Outline Diagram of Parunak's topologies (after Parunak 1989)

Parunak stated that some topologies defined a unique path between any two nodes, and that other topologies permitted multiple paths. Parunak looked at navigational aids in hypermedia such as beaten path mechanisms, which could be compared to the most used method of navigating and was commensurate with the idea of having a user's history. He argued that links between nodes should be classified and of the need to employ a method of formally linking nodes, as this would allow all links to be analysed and compared. Parunak proposed the use of maps, which would represent levels of structure, and indicate the importance of certain links, as well as providing a geographical/ graphic method of relating the nodes. Parunak's linear topology was straightforward and could be related to a common or general and least sophisticated linear pattern. His linear diagram indicated that it was possible to visit different nodes at different levels within the software, but also to simply go directly from one node to another. If the intention was to move from node to node and not to move down in the software, this linear topology could be comparable to a purely linear pattern. If the movement was potentially down into another depth or level then that could represent a star or even a hierarchical pattern (if continued on). The simplicity of Parunak's diagrams could lead to misinterpretations of exactly what movement he envisaged for each pattern. Fig 3.2 (overleaf) outlines Parunak's series of topologies with information provided by him for each of the different types. The potential differences in the route were unclear and further development of his series into a definite classification was necessary. There were similar problems with some of his other topologies. In the hierarchy topology all the links pointed away from the root, each node could be reachable from the root, but only in a set sequence and there were no returns or two-way activity in Parunak's interpretation, which did not allow the user to return and then try another linked tree.

Parunak's Hypertorus topology was a valuable design structure for multimedia, and an ideal one to allow freedom of movement and user directed navigation. There were few multimedia packages that conformed to this structure, and this made an assessment of the significance of this structure difficult. A potential disadvantage of this structure was that the user could navigate virtually from any node to the next one in the hypertorus, without any indication of their search relevance. It would also be difficult to maintain a specific navigational pattern, as at each stage all routes were similarly open. This structure required all the component information on each node to be of similar content and significance and to have no significant order in how the nodes were considered. The hypercube topology gave the user freedom, but allowed little control either directly by the user or teacher. Relatively few topics could be dealt with like this with all topics having equal connections to all others, and no hierarchy or order, although it works for basic information structures.

The Hypertorus structure had the potential of being a key multimedia structure if some method of weighting links or defining thematic structures within the hypertorus could be developed. The navigational problems associated with selecting the next node along a path, Parunak argued, were comparable to those of going to the next target node. If this situation was the case, there would be little potential benefit to using his strategies such as the path strategy, and this supported the view that Parunak's strategies were components rather than complete patterns. This questions the use of strategies as components of navigational patterns, but does support using his topologies as more recognisable and functional patterns. The DAG (Directed Acyclic Graph) topology allowed movement across more than one hierarchy and was similar in structure to the hierarchical topology. However crossing from one tree to another did not represent a strict hierarchy, and Parunak therefore separated these two topologies/ patterns (Hierarchy and DAG). From a more practical viewpoint in terms of using multimedia rather than for describing mathematical models (where these terms were specifically used), there may be little difference in how the Hierarchy and DAG patterns were actually used.

Parunak's Topologies
Linear Topology
• Specifying that each node has, at the most, one child and one parent
• A one-way linear route or a ring
• As one parent/one child criteria, there was a necessary directionality, i.e. one way direction
Hierarchy Topology
• Initial node having no parents and all the others having one parent
Hypercube/ Hypertorus Topology
• More complex still and implies more links within the structure and no restrictions on routes
• Two-dimensional structure, which allows two-way movement from and to each node
• Hypercube, each node was adjacent to four others, one on each side
• Hypertorus structure was a more complex three-dimensional form, allows multiple/ two-way
• Hypertorus topology was more of a 3D version of the Hypercube
• Key feature was that the user could traverse throughout the structure
Directed Acylic Graph (DAG)
• That most implementations have a single point of entry
• This would remove all of the hypercube/ hypertorus structure
Arbitrary Topology
• Any connected graph, and if no other constraints apply, then only identifier, path & distance
• Partial arbitrary topology distinguished from complete arbitrary by the degree of the nodes
• Navigational problem in selecting the next node along a path, or next target node

Fig 3.2 Outline Classification of Parunak's topologies (adapted from Parunak 1989)

The Hierarchy pattern could potentially have two-way interaction (in Parunak's diagram it was only one way), as most multimedia users would need to be able to return up all or part of the branch and then go down an associated or neighbouring branch. A user might not need bi-directionality all the time, but they may have needed it some of the time, and a one-way system would be too restrictive. So although it was relatively simple to recognise single one-way use of multimedia, most of the potential users of Parunak's Hierarchy topology would want to return along the path and use another branch, and therefore the need for the hierarchical single directional use would be relatively rare. Hierarchical users may also have wanted to move on to an adjacent or associated branch of another tree, and so the DAG topology may be more valuable then the basic and limited Hierarchy topology. The Arbitrary category used by Parunak served as a collection of everything that did not fit into one of the other categories. As a result this category was likely to be large and comparable to Horney's Chaotic classification, discussed earlier (cf. 2.2). Crucially a design that limited the way the resource could be used, would limit the usable navigational patterns. Hence the design constraints of multimedia could restrict user's preferences, and the user's development of in-depth searching techniques.

3.4 Comparison of using topologies with using strategies

The different complexities of the structures of hypermedia and multimedia were crucial and need to be emphasised, as the standard hypermedia structure, with its linear and sequential nature, contrasts sharply with the more complex structures of multimedia. Evans and Edwards (1999) in discussing the differences between hypermedia and multimedia concluded that multimedia was the more appropriate of the two for a learning environment and stated:

A distinction is drawn between multimedia and hypermedia navigation, in that multimedia environments provide explicit navigation, whereas hypermedia environments provide implicit navigation (p. 151).

Parunak's realisation that there were common paths or routes was crucial for this thesis, and his proposals for beaten path mechanisms were constructive for multimedia users. These beaten paths, or most commonly used routes, could help the 'lost in space phenomena'. Using maps as an aid to navigation was not a new concept, but in Parunak's framework maps represent levels within the structure and the relative importance of specific links. This was a helpful concept and was analogous to Conklin's proposals in his seminal hypertext work (1987). The map concept enables a graphic connection between the nodes, allowing them to be given a geographic location, as well as a history or a time dimension (i.e. these nodes could be in a time sequence). Parunak concluded with the following comment:

The problem of navigation in hyperspace can be addressed by considering the navigational strategies that people apply in the physical world. The availability of these strategies in a hyperbase depends on the topology of the hyperbase (p.49).

Maps have also been investigated in several other research papers. Dias and Sousa (1997) investigated common difficulties of orientation in hypermedia investigating the use of a navigation map for help while browsing and performing retrieval tasks. Twenty-two students tested this prototype and data was collected on the scores obtained in a task-test and subject's paths. This allowed the development of a series of ratios to define the user's browsing processes. The findings suggested that the map was not effective in the ameliorative role. They concluded that a map that helps performance in a spatial context does not help hypermedia with a non-hierarchical model. However Chiu and Wang (2000) investigated the use of a navigation map in hypermedia courseware, looking at the scope of using the map to aid orientation. One hundred and forty-six fifth-grade elementary students participated in a multileveled design. This used the independent variable of the scope of the navigation map, and the dependent variable the degree of disorientation measured by the number of browsed pages, number of searching steps, and the disorientation score. Results showed that the navigation map scope impacted pupils' performance in terms of searching steps and that a larger field was better, although the field does not necessarily have to be global. Parunak made a clear connection between the structure or design of the software package and how the user navigated through it. Parunak's view that a small number of alternate routes were easier to use than a linear route was difficult to support, as a linear route must be the easiest and least problematic, but the least cognitively demanding. Parunak's proposal of limiting choice to a smaller option range was potentially beneficial, especially for novices. Parunak's purely theoretical research would have benefited from evidence and examples of his strategies and topologies. The choice of routes becomes a more interesting factor if many users select the same route, but for many different reasons.

Parunak's argument was supported by research on narrative in multimedia, where a narrative context, even with a limited number of options, was considered helpful to the student's learning progress (cf.. Plowman, Luckin, Laurillard, Stratfold, and Taylor 1999). This work is detailed later with the working strategies research. Using a design approach for investigating navigation has allowed the elucidation of a series of potential types that need to be further classified. The major benefit of this type of theoretical work was that other researchers could use it as a basic framework for empirical research. Parunak demonstrated that there was a need for a classification of patterns and the construction of this classification, with further empirical testing, was one of the main aims of this thesis. The user's reasons for following specific paths, and analyses of these paths in multimedia have rarely been addressed by researchers; and these aspects were outstanding gaps in the research literature.

3.5 Empirical research on navigation strategies

Wright and Likorish (1994) investigated navigation strategies in interactive search tasks from the point of view of design. One of the theories they put forward was that people choose procedures, or navigational routes, that were less cognitively demanding, an argument consistent with Parunak. In their experiments they found that user's navigation choices were predicted more successfully by a GOMS analysis (GOMS was Goals, Operators, Methods and Selections, after Card, Moran and Newell 1983), than by the discrete mouse clicks required for alternative procedures. The method they used predicted estimated navigation times, which they compared to each user's specific times. The selection of procedures for attaining goals varied as the memory demands for the specific task increased. This suggested that the navigation patterns of users would change with the complexity or difficulty of the set task. In addition the previously chosen navigation method was modified in a way, which 'increased its procedural length and reduced its perceptual affordances' (p74).

Wright and Likorish discovered that a potential difference existed between strategies selected by experienced and inexperienced users. This involved an inexperienced user selecting a procedure with fewer mouse clicks on items even if the 'perceptual and decision-making aspects' made the procedure slower. These differences between novices and experts need greater clarification and empirical work to determine if there were differences in navigation between experts and novices and the nature of these differences. Further experimental work of Wright and Likorish looked at navigational choices. In this the navigation route finally selected by the user was compared with the differing memory demands made on the user when selecting each alternative choice. Results showed that users were faster when using the index, which Wright et al. explained as being a result of the index table being cognitively more demanding than the menu. Not surprisingly they also found that people rely more on memory aids as the number of navigation goals increased. These studies on the designer perspective have highlighted the type of strategies and topologies that could be in-built into the design structure. The methods Wright and Likorish used were different from Parunak's and were more similar to the research on navigation tools described below.

One significant outcome of their research was that users might be faster at searching and finding specific information when using certain strategies or tools. A crucial point here was that several researchers, such as Parunak, differentiated between navigation methods and working strategies, and this distinction is explored later. If these potential strategies were linked to the outcomes from the user perspective there would be substantial improvement in how software was developed.

3.6 Navigational Software using tools

Having completed Section 1, of the designer perspective, which has concentrated on navigational patterns and software, Section 2 of the designer perspective now concentrates on the use of navigational tools. The list below details the researchers in the next part of the literature review.

Designers Perspective - Research	Authors	Location
1) Strategies and Topologies - Theory	Parunak 1989	Section 1, 3.2
2) Strategies – Empirical research	Wright and Likorish 1994	Section 1, 3.5
3) Specific tools	Oliver and Oliver 1996	Section 2, 3.7
4) Comparative usage different tools	Trumbull, Gay & Mazur 1992	Section 2, 3.8
5) Specific Tools	Allinson and Hammond 1989	Section 2, 3.11
6) Set Navigation Routes	Mischanuk and Schwier 1992	Section 3, 3.13

Examining these research projects from the designer viewpoint, the use of tools has had more investigations than other navigational techniques such as patterns or working strategies. Navigational and guidance tools have already been used to represent potential user's pathways. Although using tools could be considered as using a particular strategy, in this thesis they have been dealt with as separate entities. Tools have been used for navigation in different ways, such as: using specific tools, analysing comparative usage of different tools, and using predefined formats.

3.7 Using inbuilt tools to show navigational preferences

The research cited in the navigation patterns section so far has been concerned with adult users. However there were some research questions, which have not been fully addressed in the literature such as - were there differences between children and adults, and novices and experts? Oliver and Oliver's (1996) research project investigated how children approach multimedia use, using New Grolier's Multimedia Encyclopaedia. They gave introductory sessions to twenty-four pupils (12 year olds) of whole class demonstrations followed by two practical sessions in small groups. The children were then given a topic that involved investigating the encyclopaedia and creating projects from it and each student had at least three 30-minute sessions over six-weeks. Prerequisites for the inclusion of the children in the final sessions were the following:

- Used the computer at least three times,
- Successfully located relevant information,
- Used hyper-linking to seek associated information,
- Retrieved information in different media forms and,
- Had used available tools to copy, paste and print.

On this basis the students were all assessed as being competent users of the encyclopaedia and were given four separate tasks to complete. The methods they used to complete each of the four tasks were variable as each student could decide which method to follow. Oliver and Oliver stated that comparing the four tasks provided practical information on the three main search strategies. Each student tended to prefer one strategy to the others, and they attempted to use their preferred strategy when given a question. As it was possible to use the same strategy in each of the tasks, the majority of students did this by selecting their preferred option, even if this was not the most suitable. This limited the efficiency of their progress and in some cases meant that the correct information was not accessed. The majority of users selected the title and topic searches, with a minority selecting word searches. The results are summarised in Table 3.1 below.

Table 3.1 Questions asked of students and tools used (after Oliver & Oliver 1996)

	Students	% of students using each tool	Number Successful	% using each method
Task 1 Question What is the main use of a Jersey cow?				
Word Search	7	29	6	86
Title Search	8	33	3	37.5
Other	9	38	1	11
Task 2 Question How many pages are in the article on Robert Menzies?				
Title Search	14	58	4	25
Word Search	10	42	6	60
Other	0	0	0	0
Task 3 Question What significant events for Australia happened in 1951?				
Timeline Search	19	79	15	79
Word Search	1	4	1	100
Title Search	4	17	0	0
Task 4 Question View a shuttle launch. Which engine is started first in the launch?				
Video Index	13	54	13	100
Animation Index	6	25	1	15
Word Search	3	13	3	100
Title Search	2	8	2	100

The title search and the topic search provided the user with specific queries rather than the users making up their own queries. In some of the tasks the users located the right source of information but failed to find the relevant information. This finding was of crucial importance and was especially relevant to the design of multimedia encyclopaedia. Oliver and Oliver supported the need for specialised training in the use of interactive information sources. Students' previous levels of experience and computer confidence were significant, a fact also recognised by Trumbull et al. (1992). Those with home computers used more of the options and features and experimented more, finding shortcuts and efficiencies, while others without home computers were content to use the same strategies each time. This emphasised the need to first investigate user's previous experience and skills, e.g. using a pre-test questionnaire, which will be included in the research methods here.

Oliver and Oliver (1996) also showed that the novice's use of hypertext demonstrated that non-skilled users view more screens than experienced or skilled users, and that they do so in a non-sequential and inefficient mode. These differences between novices and experts together with their research on children's navigation patterns use have shown that there were recognisable differences between the groups but further empirical work is needed to document these differences more fully and this gap in the research review will be addressed by this thesis research.

3.8 Comparative usage analyses of different tools

Trumbull, Gay and Mazur (1992) experimented with a system, which was designed to allow users to choose their own methods of obtaining information with three built in navigational and guidance tools. These tools index, guide, and browse, were employed to move through a package called Bughouse. Index allowed the user to search through a textual description of the topics, Browse enabled users to use screen commands, and Guide provided an on-line advisor. The Bughouse program was situated in a Victorian country house and its grounds (following a house metaphor) and contained information in a variety of formats and media. The information was represented by a series of 140 events. These events included a central element; e.g. artwork, video, slides, music or text, which represented aspects of cultural entomology, and which were categorised into historical period, geographic location, actual species or a cultural theme. Trumbull et al. used forty-one students for their study. Each student used the system twice; the first use was introductory, with a general orientation to the system and an introduction to the research purpose and interests. The students were free to explore the system as they chose, and were asked to explore the material as if they were visiting a museum. After the first session they completed a questionnaire assessing their overall reaction to the program, any difficulties, perceptions of the program's organisation and their interest in topics to explore further. In the second session they explored one of three focus studies.

In the results four distinct groups of users were identified by their preference for a navigational tool. Trumbull et al. termed these users: - Browsers, Indexers, Guiders and Mixed, according to their most prolific use of each specific tool or a mixture of these (Mixed). These groups were identified by selecting individuals who followed the set criteria by using one specific search mode for a percentage of time, which was at least one standard deviation above the mean percentage of time of use for the entire group. These tools were further described as: - a Browser which allows users to move through a metaphorical house, the Index which was similar to those in books and libraries, and the Guide which makes suggestions about future visits based on user's previous paths. According to Trumbull et al.'s results, the first group used the Browser for 89% of time, the second group used the Index for 65%, the third group used the Guide for 26% and the fourth were a Mixed group. They also investigated a potential connection between ability and selected navigational tool by analysing the grade point averages of all students (2.9) and of each group - Browsers - 2.9, Indexers - 3.3, Guiders 3.1 and Mixed 2.7.

Table 3.2 Comparative use of each tool in assigned groups (after Trumbull et al., 1992)

Tool Used User Group	Browse % Time	Browse Mins. Use	Index % Time	Index Mins. Use	Guide % Time	Guide Mins. Use
Browsers	98%	76.0	1%	1.1	1.0%	1.1
Indexers	14%	8.5	85%	53.0	1.1%	0.8
Guiders	47%	31.0	10%	6.5	43.0%	29.0
Mixers	58%	44.0	37%	28.0	4.2%	3.0

The Indexers had the highest grade point averages; followed by the Guiders and then the Browsers, with the Mixed group the lowest average grade point. Table 3.2 shows percentage time/ minutes for each group in three navigational methods: browse, index and guide. The tool they used most identified the groups, but they all made substantial use of other tools, except for the browsers.

3.9 Discussion of navigational tools

In Table 3.2, the Browser group was clearly defined and these users took only a very cursory look at other methods. The Indexer group did use browsing for some of their time, but for a smaller amount of time than for the index, perhaps using Browse to orientate themselves and then the Index as the quickest method of obtaining the required information. The Guiders used Browse more than Guide, but were classified as Guiders because of their relatively significant use of the guide tool. The Guider group was interesting both in how they spread their time, and in their use of the index. The final group, the Mixers, used browsing predominantly, then the index and lastly the guide. Trumbull et al. commented that the Indexers did not experience the program fully, or were less willing to think about how the material was organised, because they had relied on the known device of the index. This may have reflected factors such as the Indexer's potential greater experience or that they were more goal directed, but there was no evidence to support this.

The apparent poor quality behaviour (noted by the researchers) of the Indexers group contradicted the grade point average results, and highlights a very difficult area to investigate. The grade point average may be an indication of the amount and nature of the work these students did. Trumbull et al. examined the amount of time it took students to complete required tasks, (Table 3.3) and which group were faster and more efficient at retrieving the information. In the first session students took an average of 42 minutes. In the second session the Browsers and the Mixers took slightly longer than the others. Table 3.3 (overleaf) outlines relevant visits, the number of repeat visits and the percentages of users finding most or all of the relevant events, with an indication of how sure they were of this. The Guiders were confident on having found most or all of the relevant events, (100% response), compared with the Browsers at 70%, the Indexers at 50% and the Mixers at 31%. The Browsers spent the longest time on the program but also visited the largest proportion of relevant events, visited them several times, and were sure of having visited all the relevant events. The Browse strategy allowed the users to use the house metaphor for orientation, and was more intuitive. The Indexers visited fewer of the relevant events and rarely revisited. Relevant entries may have been missed because the Index could not be related directly to the focus questions.

Table 3.3 - First and second Use of the package (After Trumbull, Gay and Mazur 1992)

	First Use				Second Use						
Search Mode	Mins Used	% time in mode			Mins Used	% Rel events	SD	Repeat visits	SD	Most Events Sure/Unsure	% All Events Sure/Uns%
		Br	In	Gu							
Browser	39	94	4	2	79	46%	16%	4.7	2	70/ 30	0/ 0
Indexers	45	68	26	6	62	26%	10%	1.5	1.5	50/ 25	25/ 0
Guiders	44	91	6	3	67	36%	14%	6.4	5	100/ 0	0/ 0
Mixers	42	83	12	5	75	35%	16%	4.5	3	31/ 31	12/12

3.10 Summary of the use of navigational tools

The use of specific tools was complicated by the fact that Trumbull, Gay and Mazur compared each user's use of each tool with the 'normal use'. They determined that if the user had used a particular tool for more than the standard deviation use they would be classified as having used this type. This has caused problems with some of the tool usage results as some users used more of a particular type e.g. the browse tool, but because their use of less common tools such as the Guide was high, they were classified as this type. Concerning the different methods used by the students, with the Indexers half of the responses were unconnected to the questions asked, and the Mixers and Browsers were generally more aware of the spatial/ thematic organisation within the package. Additionally in the first use of the package, 85% of the students used at least two different search modes and 63% used all modes. Trumbull et al.'s argument, that the Indexers did not experience the program fully, as they were not aware of the house structure and how the material was organised, was valid. However they proposed that the Indexers, or more direct learners were those with higher ability and therefore preferred to use Index methods (such as linear search patterns). Previous research proposed that it was the more orthodox and less creative user, rather than the more intelligent one who follows linear strategies.

The relationship between the user's prior knowledge, the strategies and tools used, were crucial in this research. The relationship between ability and navigation methods has proved to be a difficult one to ascertain. Trumbull, Gay and Mazur related higher and lower abilities with the way users preferred to use software. They concluded that students used search features differently, that different search modes affected the amount of information found, and that certain tools were faster to use than others. Student's comments on the information organisation show that there were significant differences in their perception of the house metaphor and they found analysing the layout of packages difficult. Only half of these students recognised the use of the metaphorical house as an organising image or metaphor, while less than half realised that certain topics were located in expected places in the house. This demonstrated that the software structure affected its interpretation, and that specific metaphors may not always be understood, or understood in the same way, by all users. The fact that the house metaphor, a common and well-known structure, was not interpreted in the same way implies that less well-known metaphors may have had an even poorer response and understanding. Trumbull et al. comment on a viewpoint that will be explored here, as different interfaces will be needed to support different group and individual preferences:

Findings suggest that hypermedia system designers must develop a variety of interfaces to facilitate user searches, while attending to user needs, the task and the environment (p.315).

A significant outcome was that as the students used different strategies, designers should develop interfaces allowing use of different search strategies. These findings were consistent with Horney's proposal (cf.2.4) that if users have preferred strategies these ought to form the basis of a work scheme or preferred method within the multimedia design. This core function for the design process to facilitate the development of the user's preferred method of navigating or working was a key feature that this research will elucidate. The research outcomes could then be used to develop individual and preference based multimedia design.

3.11 Navigational software and in-built guidance tools

Multimedia could be designed with specific navigational and guidance tools embedded within the structure. Trumbull, Gay and Mazur have asserted that users employed navigational and guidance tools differently, and that search modes affected the amount of information found. Other researchers have investigated the issue of whether using different tools affects the amount and nature of the information discovered. Allinson and Hammond (1989) commented on this issue in their research on the use of a travel holiday metaphor. The main mechanism for tutorials in their research was the guided tour. There were dynamic maps that allowed the user to see where they were, and indicated linkages; there was an index and features such as multiple-choice quizzes.

Table 3.4 System usage and use of navigational tools (after Allinson & Hammond)

Type of System usage	Percentage Use	Percentage of Students using method	
Browsing	88%	Hypertext links	100%
Information search	86%	Tour	91%
Revision	51%	Index	79%
Integration +other teaching	32%	Map	74%
Seeking references	10%		

Allinson and Hammond looked at four navigation methods (Hypertext, Tour, Index and Map) employed by 42 students using the system for 30 minutes (Table 3.4). They stated that although these usage figures were encouraging, it was possible that a significant number of users only employed one method of access, and used it regardless of its efficiency. Table 3.4 shows 100% usage of hypertext links, and preferential use of Tour as opposed to the Index /Map tool.

Table 3.5 Tasks and the preferred choices of navigational tools

Task	Most popular tool	Second most popular tool
Browsing	Map	Index
Information search	Index	Hypertext
Revision	Tour/Hypertext/Index	- all equally popular
Seeking references	Index	Hypertext
Study of unfamiliar material	Tour	Index
Study of partially familiar material	Map	Index
Study of familiar material	Hypertext	Index

Table 3.5 relates the task to the two most popular navigational tools and relates tool use to prior knowledge with different tools. This indicates that not only was the type of task a discriminatory factor in the choice of tools, but that the level of the student's knowledge affects their choice. Finally the index, an obviously linear tool, was the first or second choice in all cases.

3.12 Conclusions on in-built navigation/guidance tools

Using tools in navigating multimedia has demonstrated the complexity of the different tools, and the different user needs e.g. novices compared to experts. Differences between novices and experts as well as children and adults will be investigated in this thesis. The research review showed that novices prefer linear, structured methods that they were familiar with, such as indexes. Empirical work was needed to clarify these preferences and relate the experience/ skill levels of the users to navigational preferences. The research showed that the amount and nature of prior knowledge affects the navigational patterns selected. Crucially most users had particular preferences for certain types of navigational tool (e.g. an index or a linear pattern), as well as the way they preferred to work (e.g. browsing or overview then subject selection), and this varied between individuals. The mix of tools and the time usage of a specific tool varied, and less experienced users were more reluctant to develop their expertise with another tool.

3.13 Using predetermined navigational patterns

Another method of investigating navigational routes was the use of audit trail packages. In this example these audit trails represent system-defined patterns rather than user defined patterns. Misanchuk and Schwier (1992) discussed audit trails. These audit trails recorded each screen that the user visited, giving information such as the number of repeat visits, how long the user spent on certain sections, which screens they choose to visit, and their order, and the exact paths they took. The concept of observing users and analysing their paths through multimedia was a core element of this thesis. However the research work of Misanchuk and Schwier differed from this as they looked at prescribed paths set up for the user to use. It was essential for this thesis' research that the potential routes were not pre-planned for the users but that they were free to select where they wanted to navigate. The research detailed here did exactly the opposite of this and controlled the potential paths the users were allowed to take. However the outcomes from this research gave valuable pointers of the effect that this control over navigation had on the users. Misanchuk and Schwier identified four distinct types of audit trails, although significantly they stated that the user often combined these trails, and that they were both controlled and defined. The audit trails represented system defined patterns of navigation. The four types of audit trails that they recognised were as follows:

1. Linear
2. Classic feedback loop branching
3. Learner controlled parallel path branching
4. Multimedia/ hypermedia

The Linear trail was the basic one way linear path recognised by several researchers, allowing all users the ability to go through the same experience, following exactly the same route. The second trail, loop branching, occurred when some paths re-converged at the same point as they diverged, thus creating a loop that returned to the point where the user left. Their third trail, learner controlled parallel path branching, occurred where linear or branching paths run parallel to one another, and where convergence came further along the path. The user using this trail continued along the instructional sequence but joined it further down the path, making it different from the loop branching route where the user returned to the original starting point. This third pattern was comparable to the hierarchical pattern as it allowed the user to go through alternative routes and/or to continue. It was similar to a circular pattern as it allowed looping within the structure, but their diagram indicated alternative routes within a structure, rather than a true circular path.

The final trail, which they termed as hypermedia/ multimedia, was the most complex, and had both dependency and looping problems. It was more variable than the others, in terms of the number and kind of choices, as well as where the user could choose to go next. They determined two main types of hypermedia structures, the first where movement was along structured (and formal) paths and allowed less learner control, and the second largely unstructured and allowing greater user control. All of Misanchuk et al.'s patterns related closely to formal structured sessions, and to hypermedia, where there was a prescribed path for students to follow. Although there were some alternative paths, these were restricted, and returned the user to the prescribed route. This route restriction could be explained by the rigid, less flexible structure of hypermedia and was not as applicable, or as problematic, to multimedia where options allowed more complex routes.

The significant difference of the Mischanuk and Schwier (1992) research compared to other cited research was that they used program structures rather than user determined preferred routes to investigate navigation. This signified a major shift in the conceptual framework, but was included here as the designer could set navigation paths, which users had to follow. The loop branching path of Misanchuk and Schwier resembled Horney's star pattern (cf. 2.4). Horney's star was a 'user-defined' pattern, and differed substantially from this system-defined pattern, but both of these patterns, despite their different origins, have the same outward and backward movement. In the classic feedback loop trail there was also a linear element. There was a lack of clarity on audit trails. The difference between the researchers, who observed what users did and recorded these and the trails that the user selected, presumably deliberately, was a valuable distinction. Misanchuk and Schwier referred to Parunak who emphasised that the problem of navigation in hyperspace was significant, as the possible hypermedia structures that they had recognised, were reasonably close to the patterns that Parunak believed users had chosen when navigating multimedia resources. Creating multimedia software with these types of structures would allow users to select their preferred navigational patterns from the available options. Horney (1993) noted that some authors assumed that reader's paths were constrained by the topology of the software.

He cited Misanchuk et al. as an example when they stated that audit trails differed according to the program, by considering the user's navigational strategies in the real world. Horney's statement that users' navigation was constrained by the software authors who forced readers into particular styles of navigation, demonstrates a significant effect by the designer on the user's perspective.

3.14 Discussion of all the Designer Issues

Using the designer approach has highlighted several issues that affected how designers constructed multimedia software. Search techniques were often combined within a package. Users often re-used previously navigated routes and these cases have shown the importance of specific navigational routes such as tours or guides. Search options were used differently and although the requisite resource area was often found, there was often a failure to find the relevant information. Different search modes affected the amount of information found and the time taken. Preferences were also noted in the use of specific tools and guidance methods. The structure of the software packages affected their interpretation, as users interpreted familiar metaphors such as the house differently. There was an association between the user's prior knowledge, skills and abilities and the patterns and tools used. As a result there was a definite need to develop different interfaces for different users. Several researchers indicated that users preferred specific navigational patterns and that multimedia design needed to incorporate different navigation patterns. The literature review has identified three significant gaps: firstly, and significantly for this thesis, the lack of a specific navigation pattern series, secondly the need for greater clarity in the navigation of specific groups of users especially novices and experts, and children and adults, and thirdly little work on the individual user. Table 3.6 (overleaf) lists each research project and compares key elements of each research project.

Table 3.6 Comparison of different research projects

Design Issues	Project	Task	Outcomes	Navigational patterns	Main Features	Problems/ Future Work	What's Important	Gaps Noted	Significant For Thesis
1) A Parunak 1989 No users B Parunak 1989 No users	A - Strategies Theory -no empirical work, B - Topologies - Theory -no empirical	A -Theories of users navigating in component elements B - Develop a hypermedia taxonomy of topologies	A -Series of strategies of types of paths users may employ B - Potential paths and graph theory models of how they operate	A -Identifier, Path, Direction, Distance, Address, B- Linear, Hierarchy, Hypercube/ Hypertorus, DA Graph, Arbitrary	2 way approach – strategies/ topology, classifying methods of navigating & use, theoretical perspective	Needs practical application. Some strategies not useful, topologies may have large nos. as broad classification – needs refinement	Links strategies & topologies, beaten paths & navigation aids, classifies links + nodes proposes using maps & levels of structure, imp. of certain nodes	Theoretical, no empirical work, test theories, broad classification broken down	A -Need for classification of navigational routes
2) Wright & Likorish 1994 12 Users	Navigation strategies in interactive search tasks	Different tasks using different strategies?	User's navigation predicted using GOMS. Users faster using index, more mem. needed -more navigation goals	Index Menu	Navigation choices by GOMS analysis, Goals, Operators, Methods, Selections	Reliance on memory increases + navigational goals, but insufficient exploration, cognitively more demanding routes	Users choose less cognitively demanding procedures. Estimate navigation times, compare users	Work needed on: users faster using certain tools, pref strategies diff. tool use	Users faster/more successful using certain tools/strategies
3) Trumbull, Gay and Mazur 1992 41 users	Bughouse package, house metaphor	Searching for specific info using text artwork, video & slides resources	Users preferred certain tools & continued using them, diff. search modes affected amount info found	Index, Guide, Browse, Mixed	System in built tools, different groups, differences, some use more than one tool	Using different strategies but for different amounts, link with ability levels – low and high	Different usage of tools, distinct pref. For specific tools, some mixed use, pref. Determined in 1st use, cont. in 2nd	More tools could be used. Degree of multiple tool usage	Higher/lower ability link with navigational patterns
4) Allinson & Hammond 1989 42 users	Holiday travel	Questions seeking information, needing users to search database for answers	Significant num.used 1 method & continued + this regardless of efficiency. Level of student knowledge affects choice	Hypertext links, Tour, Index, Map	Link between prior knowledge + different tools, level of students knowledge affects choice	Different search strategies affect amount of info found, 100 % usage of hyperlinks. Pref. for certain tools	Significant number of users used only one method of access regardless of efficiency	Insufficient info on prior know. Need more, info on which tools selected for which task	Prior knowledge, single tool preferences
5) Oliver & Oliver 1996 24 users	Searching in a multimedia database	Given topic investigating paths & developing projects from it	Students prefer one tool over others, 3 main tools – Word, Title, & Timeline. Selected preferred tool even if not best	Word Search Title search, timeline search, video index, animation index	Define prefs. for certain search strategies, prev. experience levels & computer skills important	Users located right source not right info, home computers users + improved options, novices more sequential & view more screens	Each student preferred one strategy, students prev. levels of experience, comp. confidence imp.	Set tasks, no open tasks, no free subject choice poss. Navigation methods restricted	Definite preferred search strategies Experience & comp. confid. essential
6) Misanchuk & Schwier 1992 15 Users	Audit trails of each user	Each user searching hypertext resource, with 8 decision points recorded	Responses and audit trails for each user, series of types of path	Linear, classic feedback loop branching, user controlled parallel branching, multi-media/ hypermedia	Restriction on available routes navigation forced, choose pref. method, need for sufficient choice	System not user defined does allow choice, need to see if specific users follow these choices, could be used to observe users	Users follow distinct paths & have specific preferences for certain routes	Little info – users select paths, effect of forced routes & if users select 1+ paths	Forced navigation routes, need several choices for user

4

Pedagogy and HCI perspectives

4.1 Introduction

The information from the first two perspectives of user and designer, with the associated empirical research, will produce an outline framework from which the last two perspectives: pedagogy and HCI could be better investigated. There were specific pedagogic and HCI issues that have direct relevance to this thesis and as these specific issues are discussed later, a brief but not exhaustive summary is included here. The relevant pedagogic issues are how multimedia are used, and differences in children's and adult's multimedia navigation (and expert to novice differences) and user control and recall. The relevant HCI issues are the transparency of the interface, whether certain interfaces encourage certain types of navigation, and if users have preferences in their approach and use of different interfaces in the same software resource. The research cited in this chapter is listed below:

Pedagogic Research	Research authors	Location
1) Experts editing tasks	Card, Moran and Newell 1980	4.2
2) Expert and novice codes	Santhanam and Weidenbeck 1993	4.3
3) Expert/Novice divide	McGrath 1992	4.4
4) Expert/Novice differences	Perez, Fleming Johnson & Emery 1995	4.5

4.2 Pedagogic Issues –1) Expert/ Novice Divide and 2) Recall

Research on the expert/ novice differences between users has been included because there was a definite distinction in the literature between how users navigate, and their experience/ abilities in navigating. Card, Moran and Newell (1980) investigated experts performing editing tasks. They discovered that experts have built up a repertoire of techniques for dealing with the standard situations encountered in editing. These steps, which were required to perform a set task, were linked together and the expert only had to recognise the problem before selecting the most appropriate method. Baeker and Buxton (1987), discussed Card et al.'s work and the use of existing skills as the basis for performing new tasks and termed this skill transfer, and then developed four dictats for successfully designing an interface to maximise this transfer: -

- Build upon the user's existing set of skills
- Keep the set of required skills to the minimum
- Use the same skill wherever possible in similar circumstances
- Use feedback to reinforce similar contexts and distinguish ones that are dissimilar

Baeker and Buxton considered that, as experts were highly practised and able to recognise situations they have already encountered, the recognition and selection task imposes minimal loading and hence allows the execution of the task to be automatic.

4.3 Specific example of Experts and Novices - 1

Santhanam and Weidenbeck (1993) worked on verbal protocols using word processing software, which allowed them to access their user's thought processes. Fourteen users performed a series of tasks on a document, and were asked to 'think aloud'. The researchers selected two different word processor packages, one command driven and the other menu driven, and half the users used each one. In the command driven system editing tasks were accomplished using the appropriate command, and navigating with the arrow keys. In the menu driven system a document was created and edited in the document window, by means of the six drop-down menus (file, edit, search, format, font and document). Sixteen editing tasks were used, created from lists by random users, such as inserting, deleting, replacing and moving text. They added non-routine tasks such as super scripting, changing line spacing and setting margins and from this determined a series of codes relating to differences between novices and experts, which were as follows: -

Novice codes	**Expert Codes**
1) Hesitation or lack of confidence	1) Ability to categorise problems
2) Wanting to experiment	2) Knowledge & understanding of system and commands
3) Confused by system behaviour	
4) No semantic structure of system knowledge	3) Co-ordination of large amounts of information
5) Forgetting commands and syntax	4) Routine error recovery (realised error & corrected it immediately)
6) Production bias (finish as soon as possible)	

Despite only using a small number of students they found differences between novice and expert behaviour and compared discretionary users such as lawyers, administrators etc., with novices and experts. They used four novices and four experts on the same systems (using two of each type on each of the two systems). They found the discretionary users had limited knowledge and restricted use of the system, used a small set of core commands, only had procedural knowledge of the system, (i.e. they knew commands performed certain functions but did not know the system structure), and they needed to actively experiment. The discretionary users had more skills than the novice users, but did not have the skills or abilities of the expert users.

4.4 Specific example of Experts and Novices - 2

McGrath (1992) also looked at the novice/ expert divide with her work on learner control, looking at the conditions under which learners benefit from available choices. Her study compared students with low or high spatial skill scores, in four conditions: hypertext, CAI (computer assisted instruction), paper and program control. The users were 103 undergraduate teacher students doing instructional media courses, between the ages of 20 and 46. The students were given a pre-test about their curriculum, computer use and mathematics backgrounds, and had their skills assessed with pre and post-tests for specific mathematics tests. McGrath developed a hypertext mathematics lesson on determining surface areas of hollow figures. Different degrees of learner control were defined in versions of the same lesson. The highest degree of learner control was 1) the Hypertext version followed by, 2) Paper version, 3) the menu driven CAI and finally 4) No Menu (a page-turner with little choice). Users were randomly assigned to the four groups (34 in Hypertext, 15 - paper, and 35 - CAI and 19 - No Menu). McGrath's research with hypertext concentrated on three main questions: 1) Whether the degree of learner control with hypertext allowed users to deal with misconceptions, 2) Whether the literature consensus of high skill users doing better under learner control than low ability users was supported empirically, and 3) Whether users took advantage of being able to control the sequence of learning. Her conclusion stated that the situation was very complex. The first research question showed that the results were exactly as predicted but the differences between the conditions were not significant. McGrath stated the literature consensus was that high-skill learners do better under learner control than low ability learners. The second question comparing High and Low Spatial users revealed a distinct pattern of differences between these users. She found that high skill users: took more time, viewed fewer screens, but had fewer misconceptions than the other groups. Whereas low skill users: took less time, viewed more screens for short amounts of time, were not very efficient, solved fewer problems than others, had the most misconceptions, and made the most non sequential choices. The third question had a positive outcome but the differences among the groups were not simple ones. McGrath's work provided definite examples of differences between high and low skill users, which were analogous to the novice and expert dimensions discussed above. These differences indicated that the novice to expert divide may prove an interesting and a definable area for further research.

4.5 Specific example of Experts and Novices - 3

Perez, Fleming Johnson and Emery's research (1995) on expert and novice differences looking at cognitive models of design, demonstrated that these two groups use divergent design models. They listed attributes of experts:

- Apt to use more design principles
- Reliant on a variety of knowledge sources
- Spending more time in front-end analysis/planning and understanding the domain
- Creating breadth first design models with elaboration between connections
- Integrating, reiterating and cycling design models through the design process
- Followed an iterative rather than linear design process activity

Whereas novices were:

- Starting by considering numerous design strategies
- Creating design models which were depth first processing with few links
- Having a preference for linear activity

4.6 Summary of Novice and Expert research

The research on novices and experts has revealed a series of specific and different attributes for each group. Empirical work using novices and experts with a defined series of tasks would determine if there were distinct differences in the navigational patterns and working strategies that they employ. The literature supports the view that they bring different skills and abilities to multimedia and this was reflected in their choice of patterns and strategies.

4.7 Recall/ Retention

There are issues that affect the navigational preferences of the individual such as the prior knowledge of the user, the skills and abilities that the user brings with them, and how information is used and recalled. Although this thesis will not investigate learning, the level of recall and retention is valuable, as this signifies the benefits of specific patterns of navigation. The user's working strategies may also have an effect on recall and retention. Gagne and Glaser's (1987) research reported on the need to use both short and long term memory as well as working memory. They suggested that some information (e.g. shapes or patterns) might flow directly from primary memory to long-term memory, but the more usual route was from short term to rehearsal in the working memory, into longer-term memory storage. This movement of information into different types of memory may affect the recall and retention capacity of some users.

They commented that there appeared to be three main types of material which go from the long term into the working memory, 1) events employed in elaborative rehearsal 2) items matched with incoming material and 3) previously stored long term memory material which integrated with newly received items. This was based on the earlier work by Gagne (1977), which outlined the flow of information. He considered that information initially entered a structure called the sensory register where it remains for a short time. From the sensory register the information is moved into short-term memory (usually up to 20 seconds) before being processed into long-term memory where the information is encoded into meaningful units that are semantically organised, these 'pictures' can be matrices, diagrams or detailed images. There is some loss of the full 'picture' at each stage. Recall of what has been learned can be done immediately, but recall needs a reconstruction of the events as they were remembered rather than a reinstatement. Hence triggers or key facts are important. Allinson and Hammond (1989) carried out research in the area of recall within learning support environments (cf. 3.11). They outlined five principles for recall:

1. Encoding specificity, material can be recalled if it contains retrieval cues generated on recall
2. Encoding variability, multiple exposure to same material allows varied contexts, more cues
3. Knowledge assimilation and integration, attach new knowledge to existing structures
4. Depth of processing, exploring the meaning of the material
5. Learner control, control needed for nurturing relationship between learner, materials and learner's goals.

Allinson and Hammond proposed that systems should include the following features to promote these underlying principles:

1. Distinctive and multiple forms of representation e.g. using graphical/ dynamic presentation

2. Rich access structure with many cross-links for integration
3. The ability to juxtapose materials to help integration
4. Dynamic models, interactive demonstrations and multiple-choice questions for encouraging active learning
5. Learner control over what to learn and how to learn to suit their own goals

Allinson and Hammond in their research (outlined earlier cf. 3.11) were concerned with what information the students had retained. The four navigation methods were used by 42 students. Then they gave a free-recall test to 16 of these students a week after their session, selecting students who had used the system for an average of 85 minutes each. They found the student's breadth of recall did not match the breadth of actual usage in the software. An assessment after a multimedia session would reflect the immediate recall, but a follow-up interview would determine the retained knowledge and which navigation patterns and strategies continued in use. This second interview could be compared to the first. A final interview after the multimedia session could be included.

4.8 Human Computer Interaction and Design Issues

The final perspective on navigational patterns was human computer interaction. This relates to both the individual user and to the designer. The design of multimedia determines how the user could navigate within in it but the movement towards more user centred design structures has promoted ease of use, uncluttered screens, the use of navigational tools and flexible design practices. The analysis of the HCI issues will be more productive after the designer and user perspectives have been thoroughly investigated.

O'Malley (1989) proposed that the interface represented how the user operates in the represented world and if it was well designed the interface becomes transparent and no longer exists for the user. This allowed the represented world to be directly present and led her on to discuss direct manipulation interfaces. She discussed two ways of thinking about these, firstly as a descriptor of a class of interfaces, usually graphical, not text-based, and using a pointing device, and secondly as a theory of interaction. Research on how people work and how their learning processes were invoked and developed was relevant to the discussion on working strategies. Laurillard et al. researched narrative in multimedia as part of the MENO project (Laurillard et al., 1993, 2000). Luckin, Laurillard, Stratfold and Taylor's work (1998) on narrative made the following statement:

> Narrative can be seen as a macro-structure which creates global coherence, contributes to local coherence and aids recall through its network of causal links and signposting (p.310).

They compared linear; resource based (RB) and guided discovery (GD) versions of the same software. They found that students using the GD version had high levels of task talk and procedural talk, compared to the linear version, which had less of both types of talk, and the RB version where only the procedural talk was high. Plowman (1997) earlier stated that this gave a structure and a linear dynamic, allowing users to maintain their own plans and goals. Research cited by Plowman, Luckin, Laurillard, Stratfold and Taylor (1999) on the use of narrative by teachers, factors in the individuality of users, the social context, artefacts and the environment. Plowman et al. (1999) proposed that narrative guidance and narrative construction were interdependent. Narrative guidance comprised the design elements within the software and could be a combination of both interactive media, with such elements as navigational procedures, and traditional media such as narrative structure. Narrative construction was the active process of meaning-making together with the individual's background knowledge. They described narrative construction as a process:

> A process of both discerning and imposing a structure on the materials making links and connections in a personally meaningful way (p.311).

Their findings supported the view that user centred design of multimedia would improve multimedia and an awareness of this interdependence would lead to study benefits from multimedia. They recognised the connections between narrative as a way of connecting what goes on in the head (of the person) with what goes on in the world. Narrative guidance and narrative construction were not discrete processes but happen dynamically and the construction of this narrative needs to be a collaborative process between designers, teachers and the users themselves. Plowman et al. commented on this relationship with the following statement:

> The relationship between the designer and the user is symbiotic, each dependent on the other (p.312).

This symbiosis and the dependencies that this created are a crucial area of interest in this thesis.

5.1 Introduction to the working strategies research

In the introduction four different perspectives were highlighted, user, designer, pedagogic and human computer interactions. These perspectives will be addressed here with specific reference to working strategies, as this third part of the review describes and analyses working strategies in interactive multimedia. Although there were some similarities in the approaches used and in their characteristics, several researchers have argued that there was a distinction between navigational patterns and working strategies. The navigation patterns research concentrated on how users move through the software, while the working strategies work looks at their style or method of working, by analysing their use of search strategies, which were frequently given different names and meanings such as browsing and scanning.

Brooks, Simitus and O'Neil (1985) described four categories of individual differences, which were related to learning or working strategies. These they considered to be abilities, cognitive style, prior knowledge and motivation. The research projects, which have been briefly summarised as follows:

Working strategies	Research authors	Location
1) Search strategies	Canter, River and Storrs 1985	5.2
2) Working methods	Frau, Midoro and Pedemonte 1992	5.3
3) Hypertext reading patterns	Horney, Anderson-Inman, Chen Lewin 1994	5.4
4) Information Seeking	Marchionini 1989	5.5

5.2 Specific examples of working strategies - 1

Canter, Rivers and Storrs' (1985) research on patterns such as pathiness, ringiness etc, has already been discussed, (cf. Fig 2.4), but they also developed theories of different search strategies and how these were used. Their strategies were detailed in the following list:

Scanning - Mixture of deep spikes and short loops as users cover large area but without great depth

Browsing - Many long loops and a few large rings - users go where data leads until interest caught

Searching - Ever increasing spikes with a few loops for users motivated to find a particular target

Exploring - Many different paths, suggesting users were seeking to determine the extent and nature of the field

Wandering - Many medium sized rings as the user moves along/revisits nodes in unstructured journey.

The importance of this research was twofold. Firstly Canter at al. recognised the need to classify these strategies and, secondly, they recognised that there was a definite distinction between the user's selection of patterns of navigation and the way the user worked or the strategies they employed to work through software. Their navigational patterns had specified patterns such as ring; spike, etc. and they developed this work further by linking these patterns to working strategies such as scanning and browsing.

5.3 Specific examples of working strategies - 2

Frau, Midoro and Pedemonte's (1992) research used Terrimonti, an educational hypermedia system on earthquakes, and investigated their students' use of their own methods and solutions within the system. They looked at the way the students interacted with the software, and investigated the effectiveness and the problems of what the students were doing. Frau et al.'s study had two main aims. The first aim was to investigate student interaction with the system and answer questions such as: 'How long do students spend on each activity? In what order do they proceed? What problems did they have? How do they organise the study of the contents? In which cases do they consult the dictionary? How do they construct a mental image of the functions of the system?' Their questions were similar to those posed by Laurillard in her student assessment work (1993). Their second aim was to evaluate the effectiveness of the system in producing meaningful learning.

As there were many different elements in this they considered the quality and quantity of its concepts, types of link, the systematic and hierarchic organisation of concepts, and the lexicon, but stated that it was difficult to produce a quantitative measure of the user's achievements. They considered that different methods of approaching the system could affect learning, in terms of both its effectiveness and efficiency. They then developed a third aim of the study, which was to identify different types of strategies of browsing and compare them on the basis of the learning that resulted. Frau, Midoro and Pedemonte's two conditions, i) a self-service mode with no explicit task and ii) task guided navigation, were similar to my initial browsing task and my task based exercises respectively. The interface to Terrimonti was unusual, as the user had to select a door from a series of rooms in a museum, using a house metaphor. Curators provided information on the learning materials, (such as content, aims, references and a summary). Inside each room there were two doors: browsing and study. Frau et al. investigated the questions asked, the amount of time spent on each activity, the student's progress through the software, problems and the resulting different browsing strategies.

5.3.1 Using different environments - Browsing environment

The browsing environment allowed four different access modes:

1. Topics - arranged in a tree structure, one level available at a time, with audiovisual material
2. Maps - knowledge maps, with links to the material and knowledge representation
3. Anthology - access to articles on their theories - individual access to sections
4. Index - a list of learning materials

This browsing environment related well to the reviewed working strategies, and dividing the environment into sections for each tool allows easier relations/comparisons between these access modes and the navigational tools research. This link between the strategies used for working in a particular environment and the specific tools used, was a constructive one. There were alternative methods of accessing the same tool, and this may be a requirement of successful navigation methods, i.e. a tool could be approached in different ways e.g. the dictionary was selected by a book icon or a bookshelf. The dictionary was easily understandable being grouped by topic: e.g. photos, audiovisual, and investigations and it allowed navigation within it.

5.3.2 Using different environments - Study environment

The study environment contained explanations of the material and tests to question the user's knowledge of what they had found out. The functions available for supervisors included this list:

1. Selection of topics to match educational objectives and learner status
2. Selection of best topic to be taught next
3. Selection of best strategy for that topic
4. Select best unit of learning (ULM-unit learning module) to implement strategy
5. Select best ULM to perform the given educational function.

Frau, Midoro and Pedemonte imposed two conditions, 1) a self-service mode with no explicit task with 15 high school students (aged 14-19 years) and 2) task guided navigation with twenty-one students from the Liceo Scientifico (17 years old). The self-service condition session could last up to three hours, and consisted of a brief explanation/ introduction of the system, and individual practice, and was video-recorded. The user had no explicit task but interacted with the system, developed an awareness of the resources and obtained information on earthquakes and how they could protect themselves. In the task guided condition the experiment was divided into two phases, 1) the first involved the presentation of the Terrimonti system, a pre-test based on a conceptual map of 26 concepts related to earthquakes, and a questionnaire, 2) the second consisted of a study session (of up to two hours) for each student after a brief introduction to ways of interacting with the system, and solving a problem. The sessions were videoed and post session interviews evaluated the type of problem solutions. The results from the self-service mode were significant as although the average time taken was 1.5 hours, 66% of this time was spent consulting the study material. The results from the task guided mode showed that the time was spent studying the subject, with less time spent overall and most time spent on the geodynamics module.

Frau et al. found that 20% (a large proportion, they considered) of time with the self-service users was spent on the system, understanding and accessing functions and structures. Their results were based on comparing the student's pre/ post interviews and the changes in their concept maps. Some students acquired new knowledge in both conditions, but many students only acquired a lexicon of terms, and fewer students understood the underlying concepts. The majority of changes were in the restructuring of existing knowledge rather than understanding the models behind the facts but even the new knowledge acquired was unsatisfactory. Frau et al. could not relate the types of interaction with the system with the achievements of the students. The student's exploration of the material tended to be sequential and systematic rather than thematic and hierarchical.

5.4 Specific examples of working strategies - 3

Horney's later research with Anderson-Inman, Chen and Lewin (1994) looked at learning strategies in hypermedia and they termed these hypertext-reading patterns. This was especially relevant, as Horney (as well as Canter et al.), had developed a series of navigational patterns, and he had specifically differentiated between navigational patterns, and how users employ working strategies. Students interacted with the electronic resource in six different ways. These 'hypertext-reading' patterns were listed as follows:

1. **Skimming**, moving rapidly through text at a pace too fast for reading or studying
2. **Checking**, moving through text systematically apparently checking things out, not reading or responding
3. **Reading**, visiting pages for long enough to read the material but with little use of the resource
4. **Responding**, accessing resources, but not in a way that appears related to reading the text
5. **Studying**, moving systematically through text, visiting pages long enough to read them and using resources in an integrated manner
6. **Reviewing** reading text and/or accessing resources for a second time.

5.5 Specific examples of working strategies - 4

Marchionini's (1989) research used tasks within a multimedia encyclopaedia. He found that older searchers were more successful, and took less time, than younger ones. Marchionini stated that a system of mental models for the general problem of seeking information from a computer was assumed, and stated that an information seeking system should include these components:

> A set of mental models associated with various information sources (databases and accompanying search systems), a set of mental models pertinent to a particular information problem (task domain knowledge), an historical record of past applications of the information-seeking system (self-awareness which allows analogy and checks context), and a set of rules for combining these components and monitoring progress (p.353).

Marchionini defined the movement through the material as their Information Seeking Search and the way they went about the search as their Information Seeking Strategy. The students were introduced to the encyclopaedia and assigned two search tasks. Data was collected through observation and the student's keystrokes. All the users had computer experience, but none had used an electronic encyclopaedia, so although these students were not experts, they were not complete novices. The first task required the students to find certain facts, e.g. the first year speed skating was in the Olympic games, which combined three facets; place, activity and time. The second task needed information on women space travellers, combining the three facets: person, place, and activity. Marchionini looked at three outcome measures: - success, time to complete a search and

total number of moves (tactics) used, within a time limit. Marchionini created a 'state map', analysing where the user had been and how often, by counting moves. He simplified the state map and compared each individual's state map and stated that the users were task driven.
The state-map developed from two basic principles - lookup and examine, which were then classified as two distinct patterns. In the results Marchionini stated that all the searches had been successful, i.e. all the users had found the required material, and that the time taken was dependent on their group and task. Marchionini found that novice users could use the encyclopaedia successfully with minimum training, but that younger students (third/ fourth graders) were less successful, took longer and made more moves than older students (sixth graders). The user strategies were interactive rather than planned (issues very relevant to working strategies), and although users could identify key facets of the task they had difficulty formulating effective queries. Marchionini stated that experts find information in a more direct manner with planned strategies, and that this encyclopaedia may lend itself to 'highly interactive heuristic searching'. The novice users created mental models based upon print models, which were restrictive and less flexible and adaptable than those of the experts. Marchionini's state maps created a method of comparing the user's navigation patterns, and were potentially a valuable method for this thesis.

5.6 Summary of the working strategies research

The work of Canter et al., Parunak, and Frau et al. was significant as they investigated links between the user's working strategies and the tools they used. They have found differences in how users worked through a package and the patterns or tools they used. Horney (1993), when comparing the 'reading strategies' of Canter et al. (1985) such as scanning and browsing, stated that it was difficult to relate these to the navigational patterns he had observed. However Canter et al. had investigated paths such as rings and spikes as well as working strategies, and found it essential to differentiate between these two areas. There were similarities with Oliver and Oliver's (1996) research (cf..3.5). Both Parunak and Marchionini had developed methods of using graphs to compare user's navigation, and charts comparing user's navigation could be done for this research. The review of the working strategy research has highlighted several issues. Each researcher has given different labels to types of working such as orientation, browsing, and scanning, which make it difficult to link across the research projects, as although these strategies have been given different labels, in reality many of them have similar characteristics. The working strategies research has emphasised the need for further empirical work on how strategies were used and the constraints they impose on the user. Researchers (e.g. Parunak, 1989) have noted differences and the need to classify both navigation patterns and working strategies, and this strengthens the case for further empirical work to determine these classifications and their differences more precisely. Applied versions of these strategies, the amount and nature of the strategies employed, establishing whether or not specific strategies were linked to distinct tasks, and if specific users prefer specific strategies, all need investigating. The lack of a comprehensive working strategies classification was one of the important gaps revealed in the literature review.

6

Integrative summary and statement of aims

6.1 Introduction

The summary outlines important comparisons in the literature review and lists the gaps. The research aims and the main objective of this thesis - to use knowledge/information of user's navigational preferences for improving multimedia design were detailed. Finally the literature review outcomes are discussed.

6.2 Other researcher's navigation patterns

Canter, River and Storr's (1985) paths have similarities to those of both Horney (1993) and Parunak (1989). Canter et al.'s Path route could be compared to the Linear Traversal of Horney and Parunak's Linear topology. Canter et al.'s Ring pattern had no close comparisons, however Horney's Extended Star had some comparable features. The Loop pattern from Canter et al. was comparable to aspects of Horney's Extended Star and to some extent Horney's Side Trip, which also had loops away from the main pattern, and Parunak's Hypercube pattern allowed some looping facilities. The Spike from Canter, Rivers and Storrs bore ready comparison to Horney's Star patterns, and Parunak's Ring indicated some potential differences in level, which would become a recognisable feature of my detailed star pattern. Hence although there were comparisons there was no consensus or agreement over the range of patterns employed by users and there was a definite need to fully explain and specify each pattern type. Each pattern series was discussed earlier (cf. Table 2.1), and compared Horney; Beasley and Vila; and Canter, River and Storrs. Each of these pattern types still needed to be fully explained and specified. Parunak's classification of methods could be used for navigation and these elements could be incorporated into multimedia software design. However Parunak's classification work was only theoretical and needed empirical investigation, although there were links to other researcher's empirically observed navigational patterns (Table 3.6). Wright and Likorish's (1994) work can be related and was complementary to Parunak's as their research provided a practical approach to using strategies. Trumbull et al. (1992) looked at multimedia design in terms of the tools users employed, the navigational and guidance potential of these tools, and how individual students used them, which may be a suitable approach for further navigational research.

6.3 Summary of gaps within the research literature

Areas where there has been little research and which have the most potential for further research are listed below. These areas will be addressed by this thesis:

- Distinct user preferences for navigation patterns have not been established
- There was little data on the navigational preferences of specific groups (e.g. novices/ experts)
- There was no evidence on the effect of the multimedia design on navigation preferences
- There was little information on the user's approach to multimedia / working strategies
- There was little information on the effect of the user's previous knowledge, skills and abilities on the choice of navigation patterns
- There was no definitive, systematic and comprehensive classification of navigational patterns

Table 6.1 (at the end of this chapter) summarises the main findings from the literature in terms of the thesis issues of user, designer, pedagogic and hci issues, and working strategies. This serves as a brief resume of the literature review and highlights the significant information from the main literature sources.

6.4 Research questions for this thesis

The research issues for this thesis address the gaps in the literature review. The main research question is: **Do individuals have distinct preferences for certain types of navigational patterns?** The subsidiary questions are: How are these preferences affected by system and navigation design? Do these preferences relate to the user's approach to the software / working strategies? Are there differences in the preferences of distinct groups e.g. children vs. adults and novices vs. experts? Additionally there was a need to develop a definitive systematic and comprehensive classification of both navigation patterns and working strategies. Finally in order to investigate the knowledge, skills and abilities of the users it will be necessary to determine if these factors affect the users choice of navigation and method of working before and after the multimedia session (by means of a pre test and post test questionnaire/interview).

6.5 Thesis aims

The aim of this thesis as a whole is to use the knowledge gained on navigational preferences to improve the design of multimedia. This thesis should provide guidelines for designers, which could be used to improve the navigational facilities available for users, and to focus designer's concepts of navigation with those from a user centred perspective. The research has five main aims:

1. **To determine i) Whether users have preferences for multimedia navigating and ii) What these preferences are**
2. **To provide a classification of both navigation patterns and working strategies**
3. **To devise a method of analysing and comparing navigational routes**
4. **To ascertain similarities and differences between distinct groups**
5. **To empirically test the classifications**

6.6 Conclusions of Part I

The literature review has highlighted two significant aspects of navigation research: a) the navigation patterns and working strategies research relating to the user and designer perspectives, and b) the areas with little research, and the gaps that need further research. Mayes et al. (1988) have argued that the interface needs to become cognitively invisible, and that future developments of multimedia interfaces should take us nearer to that goal. O'Malley (1989) and Wenger (1971), support this view as they have argued for transparent and unobtrusive interfaces respectively. If multimedia has these qualities it will be intuitive and easily operated by the user. Kozma (1991) stated that research on complex multimedia has produced novel questions:

> (Which) require an understanding of the moment-by-moment collaboration between the learner and the medium (p204).

This understanding will be developed here, as the first two perspectives (user and designer), are empirically tested by observing users with multimedia. The major area that was sparsely covered in the present literature was that of analysing the routes individuals have taken through multimedia. This literature review has analysed the available patterns and argued for a more systematic and comprehensive pattern classification. The most valuable information on navigational patterns from Horney and Parunak form the basis of the development of a series, with Horney producing a practically based navigation series and Parunak describing a theoretical (but unvalidated) series.

There were four main areas of concern: firstly the exact specification of each pattern has not been detailed and needs further clarification and expansion, secondly Horney and Parunak's patterns need amalgamating to provide an effective foundation, thirdly there were differences in interpretation which need resolving and fourthly there were gaps in the sequences. A full sequence of patterns could be developed and empirically assessed for actual user's patterns. Researchers such as Canter et al. (1985) and Parunak (1989) have presented a case for differentiating between user's navigational patterns and their working strategies. There was a consensus in the research cited that navigational patterns were related to user's preferred methods of working. Parunak considered that the problem of navigation in hyperspace could be addressed by considering the navigational strategies that people apply in the physical world. Horney (1993) commented on Parunak's work:

> Reader navigation is constrained by the prior decisions of authors who force readers into particular styles of navigation (p.267).

The contention here was that multimedia designers create software that restricts rather than assists navigation. Awareness of this issue would create better software, but designers and users must be aware that the design structure could limit potential navigational patterns and potential user preferences. Finally Canter et al. stressed the need for assessing different types of navigation:

> Clearly the time is right for a systematic study of these different types of navigation as a preliminary to making facilities available for them in the coming generation of software (p.93).

Table 6.1 Summary of literature issues on Navigation Patterns

Dates for each researcher are shown on the first reference, subsequent ones are same unless stated

User Issues

- Previously chosen navigation method was modified for new search - Wright & Likorish 1994
- Navigational routes that appear less cognitively demanding were selected - Wright & Likorish
- Trails were often combined by the user within each package - Misanchuk & Schwier 1992
- Readers often forced into particular styles of navigation - Horney 1993
- Different navigational patterns were linked to the user's traversal methods - Horney
- Distinct preferences for certain types of pattern - Beasley & Vila 1992
- Options of choice & user preferences only recognisable with free movement Canter, River and Storrs 1985
- Link between higher / lower abilities and the way user's prefer to use software -Trumbull, Gay & Mazur 1992
- Specific tasks that were set in the user's own work were essential - Horney

Designer Issues

- Structure of the software package may affect its interpretation - Trumbull et al.
- Less well-known metaphors have even poorer response than familiar ones -Trumbull et al.
- Front end had a considerable effect on navigation - Canter et al.
- Good command of the instruction set allows users an ability to navigate rapidly - Canter et al.

Pedagogic Issues

- Prior knowledge shown with different tools - Allinson & Hammond 1989
- Student's knowledge/task types discriminatory factors in tool choice - Allinson & Hammond
- Student's previous levels of experience and computer confidence were important - Oliver et al. 1996
- Students with home computers used more options/features & experimented more - Users previous experience and skills assessed by means such as a pre-test questionnaire - Oliver et al.
- Lower ability users - non-linear or exploratory route, higher ability users, linear - Beasley et al.

HCI Issues

- Students used features differently e.g. search option - Trumbull et al.
- Relationship between user's prior knowledge, strategy used & tools selected - Trumbull et al.
- Right source of information located, but failed to find relevant information within - Oliver et al.
- Time constraints - Certain tools faster to use than others - Trumbull et al.
- Faster when using the index - Wright & Likorish
- Certain movements too time consuming - Canter et al.

Working strategies

- Each student prefers one strategy, used preferred one even if not most suitable - Oliver et al.
- Successful search method adopted to the exclusion of all the others – Canter, Rivers & Storrs
- Navigational patterns were linked to users preferred methods of working - Horney
- Final selection of navigational choice likened to the differing memory demands - Wright et al.
- Different search modes affect the amount of information found - Trumbull et al.

Part II Methodology and Software

Part II Contents:

7

Methodology

7.1 Introduction

The chapter starts by outlining the research methods already used in multimedia research and the reasons why these may or may not be suitable for this research. The introduction and the literature review have stressed the dual viewpoints of the designer and user perspectives in multimedia navigation. This chapter details how the empirical work elucidated these two perspectives, the methods used to set up the sessions, and how the research outcomes would be analysed. The tasks are detailed which were: pre and post questionnaires, systematic observation, and interviews. The software used in the studies together with a short description and screen views is explained. Finally the research questions, linked hypotheses and analytical methods are examined. Reeves (1990) argued that an approach using multifaceted evaluation methods, as proposed here, facilitated the understanding of complex and difficult phenomena. These issues of complexity apply to multimedia. Reeves was highly critical of research that simply found out whether or not users liked a program, or which only checked out particular functions. His approach also consisted of having pre and post testing, (as used in this thesis) where the user is given a questionnaire before and after the observation session. The proposed framework for the research was also supported by the mathemagenic environments described by Lebow (1993) and Laurillard (1993). These environments need full investigation with users to determine their navigational patterns chosen in a real application, but there were no mathemagenic multimedia packages available.

7.2 Research Design

Chapter 1 outlined the designer and user perspectives for navigation. From the literature review the most significant gap that was recognised was the lack of an analysis of navigational routes and the need for a classification of the navigation patterns. From this classification groups of patterns that users employed and their preferences for them could be highlighted. The research question that was formulated was **Do individuals have distinct preferences for certain types of navigational patterns?** The research design needed to elucidate these navigational patterns and to investigate an individual's multimedia use from the designer's and user's viewpoint. The empirical research was divided into two studies, a first and second study. The first study was designed to investigate children's preferences in navigating, and concentrated on the designer perspective issues. This relates to the subsidiary research question - Are there differences in the preferences of distinct groups such as between children and adults and experts and novices? The second study was set up to assess adult's patterns, preferences and working strategies. The second study further develops the main research question and should provide both answers to the question on adult's navigation patterns and insight into the second subsidiary question on whether the preferences relate to the user's approach to the software and their working strategies. Finally the outcomes from both the empirical studies should give some insight into the final subsidiary question - How are these navigational preferences affected by system and navigation design? The research methodology has been designed with these questions in mind. The change from children in the first study to adults in the second study was necessitated by the limited range of navigational patterns within the children's preferences on navigation patterns and the relatively few children who were expert computer users or even experienced in using computers, let alone multimedia. The adult users in the second study had a wide range of computer skills, abilities and experience and this was conducive to producing a wide and comprehensive range of navigation patterns. The methodology has also been changed to reflect this shift in emphasis. Finally the results of the navigation patterns and working strategy work were assessed. After this analysis it was considered important to have the classification of the navigation patterns validated by an expert panel, (the results of the expert panel are in Appendix 5, but the discussion of their responses is in Chapter 15).

7.3 Research methods available for use

Several methods of approaching the research were investigated (from those used in previous studies) to determine which were the most suitable methods to answer the research questions for this research. Different options were reviewed and two potentially suitable methods (grounded theory and naturalistic methods) are summarised with an explanation of the method's suitability.

7.3.1 Grounded Theory

In grounded theory, Glaser and Strauss (1967) used theoretical sampling, a process of data collection for generating theory whereby the researcher collected, coded and analysed his data, deciding what data to collect next and where, in order to develop his theory as it emerged. This method does not start with a predefined theory or hypothesis but rather allows one to develop as the research progresses, a process they term 'grounded theory'. Grounded theory specifies that new developments can be facilitated by the close and detailed inspection of particular problem domains, participant's accounts and associated phenomenal and social worlds. Beneficially for this research, grounded theorists focus their attention upon the way in which scientific work is necessarily concerned with issues of discovery or generativity. The aim of the qualitative analysis is to produce a meaningful account of the multiplicities, variations and complexities of participant's worlds. An essential principle of contemporary qualitative research is to generate theory, which is first grounded in semi-structured interviews, fieldwork observations, case studies or textual material. Glaser and Strauss's approach is particularly suited to the study of local interactions and meanings related to the social or work context in which they occur, and so is appropriate for this type of research, which is based on individual's work in a multimedia environment in a reasonably naturalistic (i.e. normal practice) setting. The type of tasks that were to be set for the users would be similar to the sort of tasks they would normally perform in multimedia software. The need to make the tasks realistic and to maintain their normal software use would be necessary to collect information on how they would normally navigate in multimedia software.

In grounded theory, data collection starts without any formation of a theoretical framework. Theory is developed from the observation data. This then leads to the generation of predictions that are then contested in further observations, which may confirm or dispute the predictions or hypotheses. In order to investigate the navigational patterns that users employed, it was necessary to observe and record the patterns they used and then to create a classification, rather than pre-setting the patterns and seeing which patterns they followed. Although the literature review had delineated the patterns previous researchers had found, this research was not intended as a validation of their work, but as an exploration of exactly what types of navigation were used and when. Once this data was collected a series of patterns could be created, and then further tested, and this classification could then be validated by a team of experts to assess their value. Gherardi and Turner (1987) made the following statement:

> A distinction in research is between that which is concerned with verification and that which is concerned with discovery. In the former type, theory serves as a framework to guide verification, in the latter, theory is the 'jottings in the margins of ongoing research', a kind of research in which the order is not very immediately attained, a messy, puzzling and intriguing kind of research in which the conclusions are not known before the investigations are carried out. (p.12)

Suchman's research, detailed below, discussed methods for the type of research question for this research, and made extensive use of the grounded theory method of investigative research. Relating the research methods back to the literature, the work of researchers such as Horney (1993), and Oliver and Oliver (1996), could be identified as being based in the grounded theory approach. Horney observed users without predetermining the routes he would later identify. Oliver et al. directed their user's use of encyclopaedia resources by asking them to investigate specific questions, but did not control the method for doing this, but observed those used by the students.

The approach of the first study in this thesis is similar as it investigates whether or not children have preferences for certain patterns and if so, what these preferences are. This enabled the methodology to be redesigned for the second study, which involved extending the study to adults and further defined these pattern preferences. The grounded theory approach does not allow for a preconceived framework, but some information was needed from the users before the sessions.

7.3.2 Naturalistic Methods

The next approach, which provided some practical methods for use in this thesis, was the naturalistic method. Marton (1981) emphasised the key element of phenomenography, the study of the differing understandings or conceptions of phenomena in the world about us, and its application to research into study methods. Users or learners themselves should be the basis for study, but research should not be based on them in isolation but on people within an educational setting or learners in a context. Marton described two types of approach, the first using objective statements and facts about the world, and the second looking at ways in which people experienced, understood and interpreted situations. He believed that this second group of issues, or perspectives as he termed them, should be used in the formulation of research questions. Although the individual user is central, the context of the educational setting is crucial as well as the methods used to teach them and the tasks they are asked to complete. When considering naturalistic settings for research Brown, Collins and Duguid (1989) argued that there is a gap between what is taught in schools, and what is taught in natural settings that aid learning and transfer. They considered that these naturalistic settings allowed an increased awareness by the user that learning takes place both in social contexts and social settings.

Resnick (1987) observed that there were discrepancies between the tasks given to school pupils and everyday world tasks. It is therefore essential to make the tasks as naturalistic as possible and relate them to normal methods of using software and representing real world events. The benefits of a naturalistic method have been maintained as the observational sessions are in a naturalistic setting. However as this thesis focuses on the user and the context within which they use software, a naturalistic approach that does not easily deal with individual users is inappropriate. Several researchers cited in the literature review have employed naturalistic methods, although their research cannot be considered as totally naturalistic. Examples of these include Canter, Rivers and Storrs (1985), who looked at users navigating interactive databases. They considered that users are aware of how to navigate through environments like a city and they should use these naturalistic experiences for navigating through virtual worlds such as multimedia. They wanted their users to have freedom of movement within the database and to be able to move where they wanted to go. Several researchers, for instance Horney, considered it imperative for the users to complete worthwhile tasks and that they were more motivated if the tasks were based on their own work and consisted of work the user themselves needed to do.

Trumbull, Gay and Mazur (1992) and Frau, Midoro and Pedemonte's (1992) research projects were set in a naturalistic environment, the first in a house and its grounds, and the second in a museum, to make the users go through each room and find different information according to where they were in the package. The research discussion revealed that not all users had understood the significance of these metaphors, or had understood the significance of these structures within the resource, not realising that different information was in different areas. There were differences in interpretation, as it was not the awareness of the setting that was the crucial element but the methods and the manner in which the users did the tasks. Horney argued for tasks that have personal value to the users. The tasks were made as relevant to the users as possible, by being realistic and developing expertise in multimedia that users benefit from in future multimedia tasks.

7.4 Research methods already used in navigational research

Pidgeon and Henwood (1997) discussed the practical implementations of using grounded theory in research, and proposed that the method in Fig 7.1 should be followed.

Grounded Theory Outline	Components	Usage in thesis
Data collection	Data Preparation	First study
Data Storage		Empirical review
Coding	Initial Analysis	Navigational Patterns
Refine indexing system - Memo writing - Category linking	Core Analysis	Working strategies -Redesign of Empirical Work - Second study
Key Concepts, Definitions Memos, Relationships and models	Outcomes	Analysis of empirical work Outcomes/ Discussion / Conclusions Verification after analysis process completed

Fig. 7.1 Grounded theory in practice and the methodology development in this thesis

Pigeon and Henwood described the process as an iterative process with the first three items following on from each other, but with reviews and returns to the initial data during the Initial and Core analysis stages. The Core analysis elements are linked and involve a circular process incorporating all the different elements (refining the indexing system, memo writing and category linking). The outcomes occur at the end of the iterative process. This outline of a research framework provides a good starting point for the empirical work in this thesis. Hussey and Hussey (1997) considered that the grounded theory approach of frequently referencing the data to develop and test theory means that this method is an inductive/deductive approach, the theory being grounded in continual reference to the data.

This again fits this thesis' research well, as the first study provides the inductive approach, while the second study is more deductive in nature. Suchman (1987) and Erickson and Schultz (1982) adopted similar observational approaches. Erickson and Schultz believed that the central issue of method was to bring questions and data collection into a consistent relationship, albeit an evolving one. This presupposed initial observation and description methods, and they stated that it was necessary to begin with observations that capture the phenomenon and presuppose as little as possible. Suchman's (1987) research, related best to the requirements of this type of empirical work. Suchman proposed that users have what she termed 'plans' of how they approach using equipment or software and that they used 'actions' to describe their working practices. These actions have to be specifically related to the situation or circumstances that the user is in. She termed these actions situated actions. Her plans and situated actions can be linked to Glaser and Strauss' (1967) grounded theory approach as both proposed as little intervention or preconceptions of theory as possible, before collecting the data. This thesis' research design has developed from this observational basis.

Suchman developed her methodology through the study of first time users of a photocopier, which had an expert help system. She rejected all the previous predetermined coding schemes and controlled experiments for the analysis of user behaviour, commenting that these presupposed a characterisation of the phenomenon being studied. She video recorded situated action, allowing the recording to be independent of the analysis, and hence avoided the usual reliance on observer's or ethnographer's field notes. Suchman used pairs of novices in order to elicit verbal information from her users, although this created an artificial situation, as most photocopier use was by individuals. In her study she distinguished between plans (which could be the sub-procedures for a machine) and situated actions (the sense that users make out of specific events). Suchman's approach is quite different from the more established cognitive science perspective as she proposes observing the user and then indicating patterns of behaviour or actions. It is imperative that the patterns that emerge are identified from empirical observational studies rather than imposed in advance. Parunak's research, cited in the literature review, has been criticised for the purely theoretical basis of his topologies because these topologies have not been tested empirically. Suchman emphasised the importance of initial empirical studies:

> Mutual intelligibility is a matter of the reciprocal recognisability of our plans, enabled by common conventions for the expression of intent, and shared knowledge about typical situations and appropriate actions, while the course of action can always be projected or reconstructed in terms of prior intentions and typical situations, the prescriptive significance of intentions for situated action is inherently vague (p.28).

Suchman proposed that the user's plans and actions are not linked to the individual's predispositions or conventional rules but to local interactions dependent on that individual's personal circumstances. The role of the individual in affecting the learning process is therefore pivotal. Suchman's research observed users using what she termed plans (e.g. sub-procedures) and situated actions (the sense that users make out of specific events). She proposed that a theory of situated action is truer to the experience of users than a cognitive account of the user's plans. This was a revolutionary theory for cognitive science, as cognitive scientists had believed that plans are the essence of human actions. Suchman stated that cognitive scientists treat the human mind as only having mental operations that are able to mediate environmental stimuli and transform mental representations into other cognitive structures called plans, which in turn produce behavioural responses. This fits well with the concept of plans being the mental strategies (or in this thesis working strategies) and the actions being the navigational patterns, which have to be placed within a specific environment or situation (in this case the multimedia package).

Suchman questioned instructional science with her views as the question of whether or not teachers follow plans when solving real world problems or whether they develop skills that are only represented by plans. Her work has been positive for instructional designers and cognitive scientists and together with her use of observational methods, and adherence to grounded theory methods, makes it a very appropriate model for this research. Streibel (1995), when analysing Suchman's work, believed that it was the analysis of the situated actions, which allowed scientists to define learning as a change in cognitive structure. He considered that the work investigated methods of using or manipulating environmental stimuli in order to develop or recognise new cognitive structures and new operations. Streibel noted that the interaction between the learner's cognitive operations and the process of the instructional system allowed the learner to construct new cognitivist structures and operations. Brown (1994) discussed novice/expert navigation differences and considered this was because the experts, unlike the novices, had plans and procedures. These differences were explained if experts developed a set of models through which they acted on situations, while the novices only had partial and often incorrect models. He considered that novices become experts by developing their knowledge in real situations, believing that novices became experts by acquiring effective discourse practices in situated actions not by acquiring expert knowledge or following expert rules. According to Brown experts are users who have acquired a disciplinary subculture of knowledge and discourse-practice. In this thesis it would be necessary to develop models for or with novices so that they could begin to use these systems, as there is little benefit in giving them expert knowledge or rules, because the time dimension means it takes significant time and multimedia exposure to develop from novice to expert.

Brown, after studying how human beings learn in the presence of intelligent tutoring systems, concluded that Suchman's situated action theory produced a more adequate account of the phenomena than a cognitive theory of plans. He then linked situational learning with situational action. In his analysis, Brown recognised three principal changes or developments made by the users in his studies during their sessions. The first was a development from knowledge to practice, the second was from problem solving to dilemma handling, and the third was from efficiency to rationality. In the first he stressed the importance of learning within a context, so that goals become expectations, and tasks were one of many activities for the learner to encompass. In the second development, problem solving became more open ended and therefore less explicit. It also had more links to problem posing and the formulating of hypotheses rather than dealing with set, predefined problems. The third development moved away from the idea of economic criteria or systems efficiency and was more concerned with what Streibel (1995) termed qualitative criteria of excellence and substantive understanding. These developments and the user's awareness of them allowed a more practical analysis of the environment and gave concrete proposals as to how Suchman's, and Brown's work could be used. Suchman used an observational approach that allowed the user freedom to perform specific tasks under their own control, with the observer simply watching and reporting on the methods employed. Brown compared novice/expert differences in normal/everyday cognition and expert cognition in Fig 7.2 below.

Everyday/ Novice Cognition	Expert Cognition
1) Act on (concrete) situations	1) See through symbols
2) Contextual sense making	2) Contextual sense making
3) Resolve emergent dilemmas	3) Resolve ill-defined dilemmas
4) Negotiate meanings of terms used to describe new situations	4) Negotiate meanings
5) Use plans as resources for new situations	5) Use plans as resources
6) Socially-construct physical and social reality	6) Socially construct physical and social reality

Fig. 7.2 Aspects of cognition between novices and experts (after Brown 1994)

Using this method when observing multimedia users would allow the individual's patterns of navigation to be recorded and these, together with an interview to allow the user to explain their decisions, would form the core part of the information gathering process. It is this individualistic approach and the need to develop and support the individual's comprehension and construction of their own knowledge and understanding, which has much potential for multimedia. The user may not have teacher assistance and needs to rely on the software for help and needs to develop an awareness of how to build and use their own knowledge structures.

7.5 Outcomes from the navigational research

After examining the present research on navigation patterns and completing a large review of multimedia packages, it became clear that there were several areas of interest that had not been fully answered by the existing research such as individual's preferences for navigational patterns and each multimedia's potential navigation patterns. There was relatively little research on group differences such as children and adults and experts and novices. As the research needed to be focused within a specific framework additional issues, such as learning process, motivation, the use of tasks, implicit and explicit tasks and deep or surface learning, except for the task work, were considered less important at the initial planning stage. Although a large-scale survey of multimedia packages – the multimedia taxonomy, was carried out in the initial stages of the research, (cf. Chapter 8) the question of each multimedia's navigational patterns was not fully explored for each package as it became clear quickly that free navigation was only available in a few packages. These are listed in the assessment of suitable software for the first study. The doctoral research focus was to investigate the navigation patterns each user or group preferred, to analyse these patterns, classify them and see if different groups had the same preferences.

The groups investigated were in two main categories — comparing children with adults, and novices with expert users. Further questions were developed, on whether each user's physical navigation patterns reflected their mental processes in working through software, working strategies and how to determine and extract these and the effect the design of the software had on these preferences. The empirical studies analysis is intended to produce the following outcomes:

1. The individual user's preferences in navigating multimedia resources
2. A classification system for navigational patterns
3. A method of recording each individual's navigational routes
4. Individual and comparative analyses of the navigational routes
5. A method of recognising / describing working strategies and the development of a classification
6. Information on how specific multimedia packages are being used by individuals and by specific groups (adult/children and novices/experts)
7. Guidelines for designers of navigation tools and techniques for multimedia design
8. Topologies of the multimedia packages
9. Methods of using each package's topology to link the these with the navigational patterns
10. Reporting the results of an expert's panel review of the navigational pattern classification and its verification as a workable series.

7.6 Participants - Choices for the first study

Choices had to be made in the selection of users and their profiles for the first and the second study. In the first study decisions were needed on the selection of the sample of users:

- Whether or not the user base in the first & second study should be large or small scale?
- Whether or not there should be a range of age groups of children?
- Whether or not the sessions should be completed by an individual or by a pair?
- Whether the pairs should be of mixed or the same gender and mixed or similar ability?
- Whether or not specific software or a range of software should be used?

The decisions made on these options were also dependent on the schools and adults involved who all volunteered and agreed to be in the research and within the time frames. It was decided that the first study sample should be of a large size (23 pairs in all – 46 children) in order to establish users preferences for particular navigational patterns and what these were. If distinct preferences were found, then the second study would investigate these preferences more thoroughly. The age ranges for the first study were considered and it was decided that different age ranges in junior and secondary school children would be used for the first study to investigate any significant differences in navigation between different age groups. It was uncertain how the youngest group (aged 6 - 7) would perform, as their lower reading and comprehension abilities would make the understanding of multimedia difficult. The youngest group was usually teacher directed in their computer work and may not have sufficient navigation skills for multimedia use on their own. Before selecting pairs for the first study, research on the benefits and disadvantages of the use of groups or collaborative learning methods was investigated.

Overall the literature on pairs pointed to benefits for pair work. Joiner (1993) found that children work better in pairs and solve problems more rapidly than when left on their own. Laurillard (1993) in her study stated that although pairs took one and a half times as long as individuals doing the same tasks, the extra time was accounted for by their discussion of plans and results, which resulted in a better conclusion. Blaze et al. (1990) identified the benefits of pairs working together, as after initially working in pairs they performed better in a further task by themselves, resulting in an improved learning outcome. They concluded that the user working alone may spend as much time planning and reflecting as the pairs do, but that the single user is unable to do this in the same way. Oliver and Omari's (1998) study used a World Wide Web (WWW) learning environment that was created using socio-constructivist instructional design principles. A qualitative research method was used to investigate the behaviours of classroom-based students (in groups) in this instructional setting. In particular the study sought to investigate collaborative learner behaviours in settings where the instructional materials involved open-ended investigations and learner support by means of a printed guide. Their observations of student behaviours confirmed that such environments can create an instructional setting, which encourages cooperation, reflection, and articulation among students.

The first study of my research assessed the navigational patterns of these primary and secondary school children and, because these children normally work together in pairs on the computer, it was a more naturalistic setting for them. Additionally their conversation together would enable some determination of who decided on the navigation, and in identifying if there was discussion on where they should go. It was considered beneficial to record the conversation of each pair, as this would elucidate each individual's navigational preferences and subsequent routes, so pairs were selected as the optimum group for the first study. The first study involved each pair assessing two software packages and the information produced across the software packages provided valuable critiques for the software designer issues. In both studies the identify of the pairs or individuals has been changed and each participant or pair has been given an arbitrary code as an identifier to enable the researcher to link each task, the observations and the interviews.

7.7 Participant selection for the first study

The children usually worked on the computer in pairs, which the teacher selected. The children were grouped into pairs; these were mostly mixed sex pairs although there were some single sex pairs. Although pairs were not ideal for specifying individual's navigation patterns, this was their normal way of working, the younger children were nervous about working on their own and pairs enabled them to discuss the navigation routes. The pairs were selected if they had satisfactorily completed a section of their work and as they liked using multimedia, the sessions proved a good incentive for the pupils to complete classroom work. Each pair had similar ability levels, but the sample covered the range of ability. Middle School pupils were similarly grouped into ability pairs, with an ability range within the whole sample. In addition as the multimedia sessions were scheduled in humanities class time, the teacher asked for some humanities content in the sessions. The assessment of their ability and concentration levels was made with their class teacher. The experience levels were assessed from the pre-test questionnaire and the pupil information. The children were seated in front of an Apple Power Macintosh so they could both view the screen, although one child would have control of the mouse. The audio recorder was placed in front of them with the researcher sitting behind them, viewing each screen, making notes and assisting only when necessary to load software or if they stopped using the computer. The information from the pretest questionnaire with the age and ability of the children informed the pair's software selection. A mixture of software was given to each group, with broadly similar coverage across the groups of each software package. Pairs were asked the questions in the post-test questionnaire, by the researcher, and the comments analysed.

7.8 Procedure - Pre and post testing questionnaires and interviews

Both pre and post questionnaires were completed for each of the users. The questionnaire design was developed after consulting resources on questionnaire design and assessment. Resources in Computer Science and in Adult Learning were assessed and the OU Project resource was consulted with the PLUM material (Plum - Programme on Learners use of Multimedia - IET, OU). The pretest questionnaire (Appendix 1) covered the user's previous computer/ multimedia use and was completed by the users prior to starting the multimedia session. The specific questions asked if they had a computer at home, what software packages they used, and general questions on subjects that interested them and their preferred methods of working through the software. The post-test questionnaire asked for factual responses to specific questions relating to the knowledge they had acquired in the test, and then continued as an interview, focusing on their opinions on the software and their method of navigation. The post-test examined their navigation choices and their approach in the session, identified problems and extracted information on their personal preferences.

7.9 Systematic Observations

Observations for the first study consisted of observing pairs using multimedia, with notes and audio recordings of the users' responses and conversations. The multimedia sessions were manually recorded for the first study, noting each screen they visited, and the package sections they used, together with an audio recording of the children's discussion. Observations were made during the sessions, with requests for information, and if the user was lost, being recorded.

7.10 Criteria for determining the empirical tasks

The research investigation on suitable types and uses of tasks drew on the work of McKerlie and Preece (1992), Jonassen and Grabinger (1990), and Tan and Nguyen (1993). McKerlie and Preece's work placed the goals of users into four categories:

1. Finding an answer to a particular question (a searching task)
2. Gaining a sense of scope for information (a browsing task)
3. Exploring a particular concept in order to learn (a learning task)
4. Collecting and tailoring information (organising and synthesising task).

These provided an effective assessment of the potential outcomes. Although they may not be exhaustive they covered the full range of types of task usually possible in multimedia and formed a good basis for producing a set of tasks for the empirical work. The reasoning behind using a range of tasks in the empirical study was that a single task would not allow the user to experiment with the package and use their whole range of navigational preferences. Using a range of tasks, as in the research literature, should allow demonstration of underlying navigational patterns, irrespective of type of task. The range of tasks would allow each user to display their full range of preferences, especially if the user repeats certain patterns, as this would suggest that these patterns are their preferential ones. The decision to use a range of tasks is particularly appropriate for the grounded theory approach as the range of navigational patterns observed would not be predetermined by a narrowly set group or single specific task.

Jonassen and Grabinger found that three types of learning processes were supported by hypermedia: information seeking, knowledge acquisition and problem solving. In information seeking the user would search for all the available specific information about a topic, selected by themselves or the teacher, in as many ways as possible. Knowledge acquisition would develop the user's knowledge about a topic. In problem solving the adult user would be given a specific topic

and would then use the hypermedia resource to develop a solution. Using these three areas allowed the user to use a multimedia resource in a variety of ways and to develop a series of navigational routes, which could be analysed to determine if they had preferences for particular routes. To test these preferences it was necessary to employ different tasks that need alternative strategies. Tan and Nguyen (1993) determined four models for computer based learning instruction courseware:
Model 1 - Instructional, which covered such elements as drill and practice and could be found in tasks such as question and answer sessions,
Model 2 - Experimental, which in this case meant a problem solving approach,
Model 3 - Exploratory, which enabled the learner to explore and to use tools and materials,
Model 4 - Informational, or an autonomic approach, giving the user tools for calculations or processes allowing concentration on individual interests and motivations.

7.11 Discussion of the task selection

Jonassen and Grabinger's information seeking process can be broadly linked into three of McKerlie and Preece's categories, namely searching, organising and sequencing information. The instructional, exploratory and informational aspects of the tasks were common to all three sets of researchers. However Tan et al. and Jonassen et al. also had an additional area for tasks, which were of an experimental or problem-solving model. McKerlie and Preece referred to these issues although their interpretation was as a task that involved finding an answer to a particular question. They resolved the need to include a task of this nature by adding on to their list of suitable tasks for a user a task such as a searching task. However this searching task was not exactly the same situation, as although the task may contain an element of problem solving it is not usually designed to extend the user's abilities. The constructive aspect of Tan et al. and Jonassen et al.'s work on adding a problem-solving task into their respective task types was that they regarded problem solving as a different and distinct type of task. However in this research using a problem-solving task may prevent the user from having unrestricted navigational routes, as the specific problem may involve using specific parts of the resource and therefore not allow free access to navigational routes, so a problem-solving task was not considered appropriate for this research. Problem-solving tasks are time consuming and may be unproductive in determining navigation patterns.

7.12 Final selection of tasks

The four types of task outlined above produce a balanced approach to using software and cover the most common types of task given to users. It is sensible to include as many as possible of these distinct types, with the possible exception of a problem-solving task. Hence the empirical work tasks consisted of a browsing task, a searching task, and an analysing and synthesizing task, detailed below. The literature review explored the types of different navigational approaches used by adults, but there is no clear classification of all the potential types. There are specific patterns that have been used by multimedia. The initial part of this research investigated over 100 multimedia packages, to see if the designers had incorporated navigational options in their design. From this survey the most common types of patterns were – linear, circular, hierarchical, star and combined types. If users have and prefer to use distinct patterns, designers must be aware of these preferences and build different navigation patterns within their software. The aim of the empirical studies though was to ascertain the navigational patterns used and then to classify them rather than matching the navigational patterns used to existing pattern structures. Restricting navigational routes or forcing users through specific routes (unless essential for specific activities -e.g. an introduction or tour) may prevent users from using the resource as efficiently as possible. As the research concentration is on designer's and user's perspectives, this symbiosis is significant here, i.e. the designer's and user's awareness of each other's options and preferences in terms of building and using the software, as well as the individual element allowing different software use by each user. The relationship between the organisational structure of the information and the potential navigation patterns is critical and the chosen software needs to allow for a range of tasks and navigation paths. These combined task and navigation paths issues were crucial in determining both the exact software and the tasks. After analysing the literature on designing and labelling tasks, three task types were selected for the empirical studies. These were: an exploratory/ browsing task (Task 1), an investigative task with an in-depth study (Task 2), and an organising and synthesising task (Task 3).

7.13 First Study - Tasks selected

Three tasks were constructed for the users, who were given two or three software packages. The first study has been designed with the grounded theory approach and so is initially quite wide in focus. The reason for this is that if it had been narrowly defined with a limited use of software or types of navigation it would not have been able to deliver the aim of the study on determining navigation patterns. There is a strong argument for allowing a wide potential of all the possible navigation options and this could not be achieved if there had not been different packages, a range of tasks and a large number of different users. An outline of these three tasks is given below:

1. **Browsing** – users were allowed a short time (15 minutes) to familiarise themselves with the package. The task was intended to assess whether or not they had any specific navigational pattern preferences, the users would be observed and their routes through the packages analysed for basic preferences.
2. **Navigation** – the users were allowed to search each package in as naturalistic way as possible, to find specific information, based on work they were doing or subjects they needed/wanted to find out. As the navigation task was designed with an investigative approach, users selected topics for the search that had some relevance to them.
3. **Layout** – the task assessed the user's views on the layout of the multimedia package. In order to complete the task the users had to select one of the two packages they had used and describe its design, internal links and how the component parts fit together.

The third task (on layout) builds on the work of Simpson and McKnight (1990) on tasks. They discovered a positive correlation between the user's ability to travel through the text in the package and their ability to produce maps of its structure. This indicated that users, who are capable of assessing how the structure is designed or are aware of the structure, were competent at navigation. Using many children and several different packages would allow an investigation of the patterns in different packages and address the question of children and adults choice differences. If only one package was selected it could not be demonstrated that the user always selected certain patterns. Using two packages would show if the design had an effect on navigation (a subsidiary question).

7.14 Discussion of the tasks and foreseeable problems

The benefits of an introductory or icebreaker type of task have been discussed. However there are problems associated with browsing tasks, and a browsing option may not be successful in view of the limited time available and the user's variable range of skills. Techniques commonly used by younger children may be repeated such as rapid clicking. This rapid clicking technique has been commented on by several researchers and refers to a method of rapid mouse clicks moving through multimedia to orientate them or to quickly search for specific information. The rapid clicking may be used to determine the packages delimiters, and although there is some adult use of rapid clicking, it is not as persistent or their main technique, as it is with the children. There is the issue of prior knowledge, where users have previously acquired knowledge of a specific subject. Some users may search for what they already know in a package, and although this is beneficial information for the observer, this may affect the multimedia use (and advantage them in the follow-up questionnaire). The browsing task could bias the user's choice of navigation patterns, as the route selected may depend on the information's location rather than their preferred navigation method but the benefits of the browsing task - a rapid introduction and total freedom of navigation were significant and outweighed the difficulties.

7.15 Methodology - Second study

The data from each pair for the first study and each individual in the second study was collected screen by screen. This had been done in the first study manually against a time sequence, so that each screen, comments or movements, time spent and pair's comments were recorded. The focus of the second study was changed to adults rather than children, in order to obtain a greater range and greater variance between both individual and groups in the navigational patterns preferences. The adults completed a pre-test questionnaire, followed by three tasks, which were observed and recorded via a scan converter on to a computer, allowing a record of their routes through the package to be maintained. The users completed a post-test interview covering the user's computer usage at work and at home, which software packages they used and their experience in using multimedia. From this questionnaire the Novice or Expert classification was made. In certain cases user classification was difficult as they could be very competent computer users but with little or no multimedia experience. For this reason another category user called Intermediate was created, of users who are highly computer literate but have little multimedia experience. The post-test questionnaire after the session asked questions about the session, the package and user comments. The follow-up questionnaire, a week later asked for the recall of events and resources used.

7.16 Methods - Second study tasks

Various different options were looked at in the process of selecting suitable tasks for assessing user's navigational patterns and their working strategies. Different combinations of the tasks were investigated, and a final group of tasks was developed. Case studies were considered with a few users following all four options of a navigation task, but as each user would have covered the same information each time, this would have influenced their second and subsequent navigation patterns through the resource, and this option was rejected. The second study tasks followed the basic first study types, but with an open rather than a layout task for the third task. The first study discussion supported the need for an initial task that allowed the user to orientate themselves within the software and this browsing task was used in the second study. The second study tasks were:

1. Exploratory or browsing task (exploratory) - Task 1
2. Investigative task involving an in-depth study (instructional and informational) - Task 2
3. Organising and collecting or synthesising task (experimental/problem solving) - Task 3

On the User perspective, the issues were: how the search was approached, the techniques used, and the eventual outcomes. On the Designer perspective, the first task analysed which software elements were used during the browsing task and demonstrated the user's interests and their navigation and work techniques. The second task investigated methods of navigating and the degree of following the set pattern within a set task. The third task investigated designer and user issues e.g. choice of subject, information availability and amount and nature of the content, with the users own choices.

7.17 Second study Tasks

7.17.1 Task 1 Second study, Browsing task

In the second study multimedia session it was considered essential that each individual user had an introduction to the package. After this brief induction the first task determined if the user had underlying preferences for types of navigational and working methods. Allowing the user access to the whole package would show what each user explored, the order, and their approach to the tasks. The first task allowed 15 minutes to investigate the package. This was introduced to the users with a familiarising session before the task and then the users browsed the multimedia package and followed their own navigation choices. The only control was advising users not to follow hot text links (due to the slow internet connection) but to record needing the link. The first browsing task familiarised the user with the package, its tools, and methods of accessing information. Using an introduction or tour would orientate them, but would miss the user's first selection, how they went about it, and their initial navigational patterns. Their ease of use in the first task indicated their level of use and familiarity with multimedia. The pretest questionnaire questioned their knowledge and subject interests, which were investigated in the initial task.

7.17.2 Task 2 Second study, Navigational Task

Three options were discussed for the second task as an investigative, in-depth search. Each option considered different ways of asking users to access information and to follow a prescribed route.

These investigations involved questions such as: how easy were each of the prescribed routes to follow, how many times/how long were users off route, do users have preferences for particular routes, and do certain routes enable more rapid task completion. The three options were as follows:

1. Users had to find four types of information in the same package, within a set time. As the information needed to be collected from different parts of the package, they would assess the best way of finding it by trying different navigational routes. In this option users would be asked to search for a range of subjects, with references to potential topics in Encarta e.g:

- Historical, which would involve using the time line (e.g. Ancient Egypt)
- Geographical, which would use the atlas and maps (e.g. Volcanoes/ Earthquake zones)
- Graphic based search (e.g. Art - information on a famous painter or painting)
- General knowledge (e.g. Inventions, or an investigation/interactivity - Ellis Island).

2. The second option was to find the same information, but within one of four set and allocated navigational routes, through the same resource. The users investigate the same subject matter but navigate through it in specific ways. The four tasks would give different views of the material and allow different but increasing amounts of user control. Examples of these routes are: linear route, timeline route (based on graphic displays), hierarchical route and open route (with relevant areas listed but greater user flexibility). Different navigation methods could be compared, seeing when and if users went off route, within time limits and with the same final questions.

3. The third option was to compare Encarta to another package, such as another encyclopaedia, by giving the user a similar task in two packages. This task would investigate the way the user actually approached the new package and if they showed the same set of preferences in the second package. It would identify any transfer of skills or knowledge gained in using the first package, into their second package use. The user may follow the same or different navigation methods.

7.18 Discussion of Second Study Task 2 options

In each of the three options basic requirements would be recorded such as each user's route, the user's digressions from the prescribed path, identifying any common routes, the use of prior knowledge and previous multimedia use, and time taken. In the first option, four different search tasks could cause difficulties arising from the information's physical layout in the package, and the amount and content across different subjects, which might affect the navigation patterns chosen. The second option with four prescribed routes, allowed an element of control over how the users navigated, and what they found, enabling comparison of navigation methods. This second option fitted in more closely with the aims of this thesis. The third option was rejected, as the benefit of completing tasks in the same package was that the user develops familiarity with it, and using a second package involved rebuilding this knowledge. This could be controlled, but time constraints and the research aims, meant using one package was the best solution. The second task allowed each user to search for topic information in four different conditions, searching the same body of historical information. Users were given one out of the four navigational routes on the same subject, the Roman Empire. This task was potentially the most significant of the three tasks. The four navigational routes were linear, circular, hierarchical and complex, with user choice increasing (and control over the user decreasing) through each route. The task for each user consisted of a specific predetermined route (allowing 25 minutes) for each user to follow. This investigated specific navigational patterns, whether or not users kept to the prescribed routes, and how often and in what manner they diverged from these paths. The last route gave a thematic approach by suggesting topics to investigate but not ordering/forcing any set route.

7.19 Second study, Open Task 3

The third task for the second study was an open or fact-finding task, based on the user's own choice of a specialised subject, and was time restricted. The adult user selected their own navigational routes, and progressed along their chosen route. This was intended to be a more naturalistic task. An encyclopaedia had been decided as the second study software, as their format allowed flexibility and the greatest number of navigation routes, it was considered vital to develop a task, which reflected user's normal behaviour. The Open task was intended to be the most naturalistic, as it paralleled the way most users used an encyclopaedia, allowing the user to select the subject they were interested in, from prior knowledge or previous searches. The observation record registered if they had already seen the information (from the earlier tasks), if it was one of their interests (pretest questionnaire), their level of knowledge, their start/approach to the search, and their use of particular tools/ activities. Looking at the sessions from both designer and user perspectives allowed the user's choice of routes and their subject approach to be examined. The user had a set time – 25 minutes to complete the task but no restriction on the area. Issues noted included offering help to users who were lost, and deciding if assistance should be provided for those off route and with problems. Significant potential findings were if the user re-employed the same techniques used in the initial task, or if they re-used the second task forced navigation.

7.20 Second study, Discussion of Task 3

There are potential difficulties when users are allowed to select their own task, as they may select a topic with too little or too much information and the users needed to choose and start researching the topic quickly. The user may spend a lot of time changing the nature of their search, expanding it, or reducing it, i.e. in refining their search methods, rather than analysing information they have found, which was essential to successfully completing the task. The information recorded may reflect prior knowledge, rather than new knowledge, and this needed assessing. The project approach, giving the user an open task to select a topic that they wanted to research, represented a real life situation allowing normal behaviour on finding out about a specific topic. This task was a productive and worthwhile task, which could assess the user's navigational routes. Allowing an open task allowed the user to: revert to their original navigation patterns (e.g. from the browsing task), to retry the second task forced navigation, or to use navigation patterns selected specifically for the task. In everyday encyclopaedia usage the tutor/user determines the subject and this task conforms to the naturalistic setting criteria, however restricting the search to a set subject might limit the potential navigational patterns. Shorter, productive sessions were envisaged, as users performed better for short time periods and suitable users would not be able to do lengthy tests.

7.21 Final selection of tasks for the second study

The final choice of three tasks resulted in a browsing task, a set route task and an open task:

- The **first task** was a browsing task allowing users to familiarise themselves with the package.
- The **second task** prescribed a set route for each user through the same information. Each user is allocated a specific route from the four routes by the researcher. The routes gave progressively more control of the route to the user, from an initial linear to an open route. Each of the four set routes is allocated to the full range of users from novice to expert.
- The **third task** allowed the user to select their own topic and to research it, for a set time.

7.22 Participants for Second Study

The question of using individuals or pairs in the second study was considered as using pairs in the first study caused a major disadvantage in that individual pattern preferences were obscured. One of the advantages of pairs is that discussion gives richer data, but amalgamating the patterns of two people did not allow analysis of each individual's preferences as a member of a pair may have compromised their own preferences. The second study looked at adult multimedia usage, and individuals allowing more analysis of the user issues for the following four reasons:

1. The first study concentrated on children and it is vital to apply similar tasks to adults.
2. Adults were more capable of, or used to, independent work.
3. Adult experience/ skill levels should give distinct groups and a greater variety of patterns.
4. Individual's navigational preferences will not be compromised/ adapted by the other user.

The second study would use twenty individual adults, and each user would complete the tasks independently enabling individual pattern preferences to be seen. Volunteer adults were sought from the Open University at Milton Keynes and ranged widely in their backgrounds; jobs, abilities and computer experience, and ranged from novice multimedia users – secretarial/ clerical staff, university lecturers, to expert users - computer programmers, graphic and multimedia designers.

7.23 Procedure for second study- Set up of Multimedia Sessions

The set up for the multimedia sessions was in an office within the Open University, to create a normal working environment. A fast Pentium personal computer was used for the majority of the sessions. On four occasions the fast computer was being used for different empirical research and a slower computer was used. The use of the slower computer was largely due to changes in the timing of the sessions by users, and providing equipment at times the users could participate. As in the first study the user was seated at a computer, in the second study this was linked to a scan converter and an additional monitor set up on another desk to display each screen they were using. A microphone was placed on the user's desk to record comments they made during the session. The scan converter picked up changes and timed them within the software with a bar on the screen. In the second study the individual user's use of each screen were recorded via a scan converter onto videotape. This produced a timed recording of each screen with the cursor movements of their progression, as well as the text or graphics used on the session.

The observer sat at another desk at right angles, behind the other desk, viewing the user, their screen and the additional monitor, which was not viewable by the user. The observer used this machine to check progress through the session. The video record contained the verbal comments made by the specific user at the stage where they were made, and linked to the screen they were using at the time. The user could ask for help only if they could not continue without help, and to talk aloud about decisions and choices of route. From all these records a graph was made on a standardised format, representing all the potential package areas and linking these through time. Analysing the patterns meant that a graph of their movements was created which was compared to other users. Each task's graphs was analysed separately, allowing groups of users to be identified.

7.24 Data analysis - Navigational patterns assessment

The navigational patterns for the children in the first study were analysed by recording each screen that the children visited, together with an audio recording of their comments. This timed sequence of the screens visited was then built up into a description of how they had moved through the package and their reasons for doing this. The data was analysed in a number of different ways. In the first study each pair's progression in the package was recorded as a sequence of the screens visited, with the comments referring to why they had taken these routes. User's comments were analysed in terms of the tasks, software, navigational routes and help requested.

7.25 Hypotheses, research questions and expected results

The outcomes from each of the tasks are expected to produce overall trends, but it is expected that the most significant effect will be different for each task. As the tasks themselves will be performed by relatively small numbers of people the outcomes will indicate trends and these trends could be further investigated with hypotheses expanding the initial research question. Hence in order to investigate the main research question in greater depth a series of four hypotheses were developed. These hypotheses in turn allowed further exploration of the main research question and encouraged analysis and discussion of the substantive issues. These hypotheses are later discussed in relation to the empirical results. The numbers in brackets refer to the first and second tasks and the task number in each case (First study tasks 1, 2, 3 - F1, F2 and F3, Second study -S1, S2, S3).

Hypothesis 1 -That each individual has preferred methods of navigating in multimedia (F1, S1)

Hypothesis 2 -That certain navigational patterns are more successful for the user than others (F2, S2), that these can be re-used (F3) and more experienced users patterns can be taught to less experienced users (S3)

Hypothesis 3 -That navigation patterns can encourage in-depth searching and potentially deeper working (F3, S3)

Hypothesis 4 -That experience of multimedia or controlled use can enhance the usage of multimedia (F2, S2 and S3)

Returning to the main research question and the subsidiary questions, these now need to be related to the research outcomes from the empirical work. The main research question was:

Do individuals have distinct preferences for certain types of navigational patterns? This question will be addressed by both studies. Hypothesis 1 will need to be proven. Subsidiary questions are:

- **How are these preferences affected by system and navigation design?** This question will be addressed in the First study Task 2 and Second study Task 2 and 3. Hypothesis 3 and Hypothesis 2 contribute to the response to this question.
- **Do preferences relate to the user's software approach and working strategies?** This question will be reviewed with the results from the First Task 2 and 3, and the Second study tasks 2 and 3. Answering Hypothesis 3 will elucidate this further.
- **Are there differences in the groups e.g. children and adults, novices and experts?** This question will be investigated with the aid of both the first and second studies and the question of experience in Hypothesis 4 is directly related to the novice/ expert divide.

Potter (1996) was critical of the view that high quality research was expected to be centred on a well-formed question or a precisely specified hypothesis. He made the following comment:

> Researchers have often found it productive to collect and explore a set of materials (perhaps interview transcripts or natural records) without being hampered by a need to start from any specific hypothesis. Indeed their devotion to a fully formulated prior hypothesis has probably been one of the reasons why psychologists have been so reluctant to study records of natural forms of social interaction such as everyday conversations between familiars or interactions in the workplace (p.130).

Agreeing with this comment and wanting to follow a grounded theory approach which goes against pre determining research questions, has meant that the use of hypotheses has been used in more of an issue or problem approach and the answers to these have come from an evaluation of the interactions rather than as specifically answering set hypotheses.

7.26 Summary of the Methodology Chapter

In summary, the analysis of the empirical studies is intended to produce the following:

1. The individual users' preferences in navigating multimedia resources
2. A classification system for navigational patterns
3. A method of recording each individual's navigational routes
4. Individual and comparative analyses of the navigational routes
5. A method for recognising, and describing working strategies into a classification
6. Information on how specific multimedia packages are used by individuals and by groups
7. A set of guidelines for designers of navigation tools and techniques for future multimedia
8. Topologies of the multimedia packages
9. Methods of using each package's topology to link the these with the navigational patterns
10. Reporting the results of an expert's panel review of the navigational pattern classification and its verification as a workable series.

The observed multimedia sessions should clarify if users have preferred navigational patterns, and lead into the user's preferences analysis. The first study is deliberately broad and should delineate the preferred pattern types and was designed to a) use large numbers of users and b) access different packages and different tasks. After analysing the first study results, the second study was given a change of direction to adult users in order to expand the range of patterns. The information on specific packages will be linked to two specific groups, children /adults and novices /experts. The first study used three tasks: an initial browsing task, a task searching for specific information, and a third layout task. The second study gave each adult user one multimedia package and consisted of a browsing /orientation task, a set route task and a final open task that allowed the user to select their own topic. A series of topologies from each multimedia package will be developed. From the results a classification of navigation patterns will be developed. The classification will be linked to the multimedia topologies, so that each navigation pattern can be shown on the topology, in order that the patterns can be recognised and the navigational paths recreated. The navigational pattern classification will then be verified by an expert panel that will compare the classification with those of two other researchers and give an analysis, which should lead to the verification of my series of navigational patterns.

7.27 Conclusions

The requirements of the research were that the empirical work software had to be easy to use, require little instruction in its use, and not require developed techniques to exploit it, as the users ranged from novice to expert. The research methods were developed for maximum flexibility for multimedia users. The first study was designed to investigate designer issues, to assess whether users had specific preferences, and to investigate the best method of determining these, by looking at suitable software and tasks. The second study concentrated on the user issues and linked the two perspectives of designer and user. The methodology proposed for this thesis' empirical work reflected the need to investigate designer issues, as first study users worked through several software packages so that designers could be made aware of the needs of the individual user. The second perspective – the user issues, were covered more in the second study, where individual users were investigated completing several tasks in the same software. This examined whether or not they always used the same patterns, whether they used newly discovered patterns and if they were able to use earlier navigation techniques in their own research areas.

8

Software

8.1 Introduction

The chapter lists the software used in both the first and second study. It details the multimedia taxonomy done as a preparatory investigation for the empirical studies. The software decisions and the first study selections are detailed, followed by the selection of multimedia software for the second study. A short description of the software packages used is included together with screen dumps from the packages. Further details of the package usage are in Part III and IV. Topologies of the software have been included in Appendix 4, and two topologies together with outline examples of how each navigation pattern was recognised are at the end of Chapter 17.

8.2 Multimedia Taxonomy of suitable software packages.

A comprehensive survey of over 100 educational multimedia packages was conducted in the early part of this research, investigating the type of package available and the possible navigation facilities within them. The survey of educational multimedia collected information on the package and analysed the structure of the package, the navigation facilities and their nature, links within the package, the text/graphics/video components, the tasks/tutorials included, the user interface and from this the potential navigation methods. The criteria for inclusion in the list of potential software were the structure, content, navigational patterns possible, suitable age ranges, and user interface. Using these criteria there were thirty-two packages that could potentially be used, and the final selection was based on the type of tasks planned and the packages that best enabled these. The taxonomy includes all the investigated packages, and covers a wide range of multimedia formats and subjects, from encyclopaedia to specific subject areas such as History and Biology. In addition a series of educational multimedia from sources such as the Open University were investigated. These multimedia packages had been developed for specific courses such as the Carbon cycle CD-Rom from the basic Science course and the Homer CD from a course on Greek literature. The taxonomy (Appendix 1) was completed as an introduction to multimedia and hence was regarded as preparatory work to the research, because of this details on the taxonomy have not been included, although the study did serve to provide the software for the empirical studies.

8.3 Software selection for the empirical studies

From the multimedia taxonomy the software was selected for the empirical studies. For the first study it was decided to use a range of software for each group, as this study investigated if children had preferences for certain types of patterns. Decisions made about the choice of software centred on whether or not software should be prescribed, or whether group members should be allowed to choose the software from a limited range. Using a single package may not have demonstrated either that they had specific patterns or if these preferences were related to specific packages, and allowing a range of subjects gave some selection options to the children, with some teacher selection, so that the software covered curriculum areas and continued work on humanities areas they had already been working on. It was essential for both studies that the selected software could be navigated through in different ways according to the individual's preferences, and that they could use it in as many ways as possible. The following list details the software that covered all or most of these criteria. Suitable software investigated included the following, classified broadly into subject area, the selected ones (bold type) met all or most of the criteria:

Encyclopaedia	Hutchinsons, **Groliers**, **Encarta**, Random House Kid's Encyclopaedia
Animal/Dinosaur	Dinosaurs, Creepy Crawlies, Dangerous Creatures
History	Ancient Lands, World War II, **Mediaeval Realms**, American Civil War, **Eyewitness Guide to History**
Science	Environment, Atmosphere, **The Way Things Work**, Inventors & Inventions, Human Body, Anglia TV
English	Crucible, Shakespeare – BBC's Romeo & Juliet
Geography	3D Atlas, Violent Earth
Mathematics	**Peanuts**, Math Blaster
General	Land & Air, The Lost Tribe, Classical Music, Musical Instruments, AP Software/ Picture Library
Open University	Homer, Human Brain, Carbon Cycle (S103)

8.4 Software used in the First Study

For the **first study** a small range of software was selected and given to each pair based on their aptitude and broad interests, and allocated to give an even spread across the whole sample. The software for the first study was selected from the multimedia taxonomy described above (and see appendix). This software was assessed as part of the initial typology work where educational multimedia products available commercially and from university courses were investigated and analysed for their content and suitability for inclusion. Each of the software packages used in the first study is described with a short description, followed by an interface screen (e.g. the main menu). There is an explanation of the children's instruction and specific tasks. The software used in the first study was: the Peanuts package, the Way Things Work (WTW), the Eyewitness Guide to History (Eyewitness), Grolier's Multimedia Encyclopaedia (GME), and Medieval Realms (MR). Each package is presented with a short resume of the package content, screen views and the topology of the package. Eighteen pairs used two packages, but five pairs used three packages.

8.5 The Peanuts package

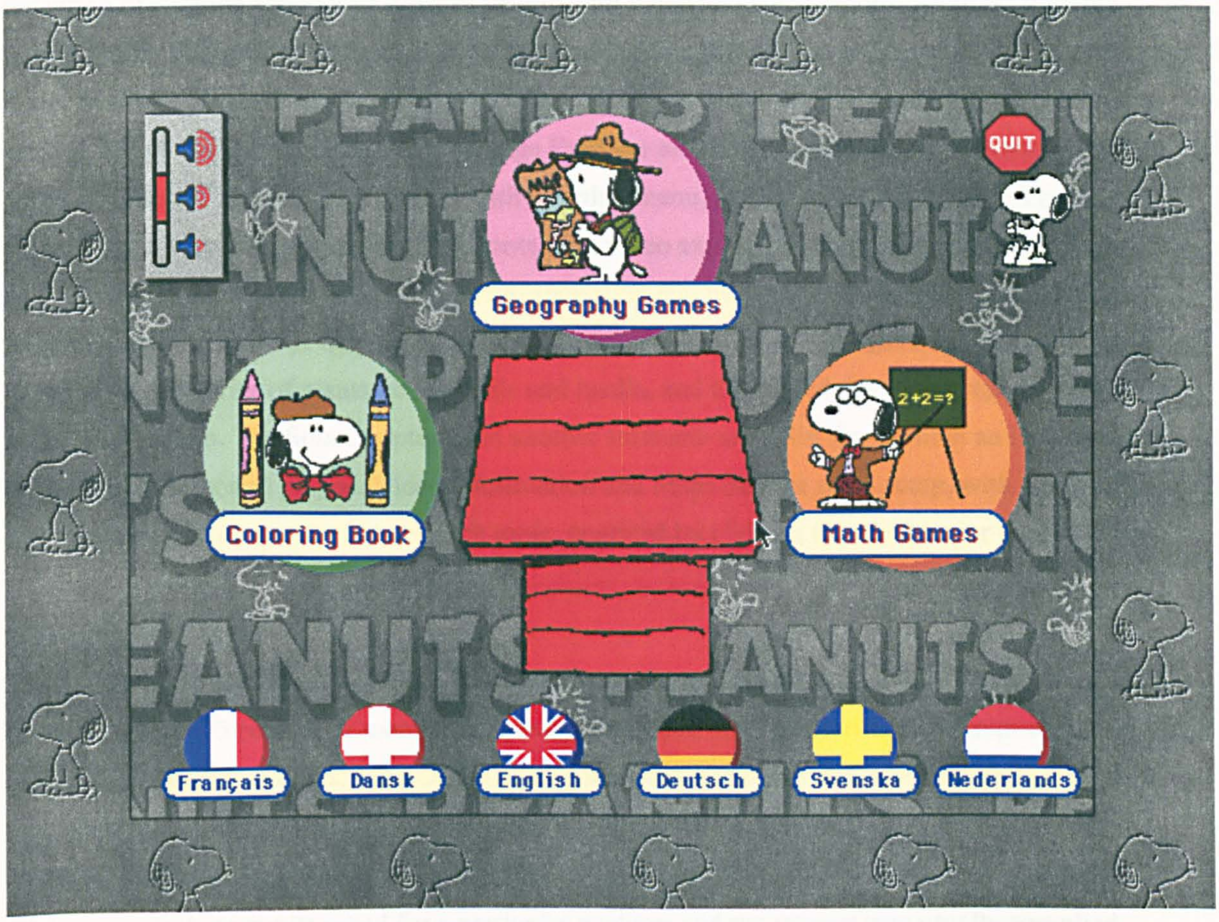
The Peanuts multimedia package was a colourful multimedia package giving mathematics and geography problems based on the Peanuts cartoon characters. The math problems involved adding and subtracting sums and scoring stars for each correct answer, with different levels of skill and complexity. The geography problems involved jigsaw puzzles of countries, looking at continents such as Europe, and rebuilding them. The geography puzzle allowed different sections of the world to be selected, but this implied some knowledge of the countries in the relevant area and their shape or name. The puzzles could be put back together either by dragging the pieces back into place or the user could be quizzed as to which country the pieces represented. The pairs were given a few minutes to browse in the package and asked to select either the math or geography sections.

8.6 The Way Things Work package

The Way Things Work package had a drawing of a workshop as the initial screen containing objects, which could be animated, and had icons, which took the user into further sections of the package. These contained information on an A-Z of Machines, Principles of Science, History and Inventors. The workshop screen was activated by selecting items on the workbench, e.g. a clock or bell that animated them, causing movement and noise. The A-Z of machines enabled the user to select a letter and then gave some examples of machines, for A - alarms; airplane and amplifier were among the items displayed. Selecting an icon allowed the user to find out more on the item. Many of the explanations have animation and spoken explanations of what the machine did and how it worked, as well as a 'see also' category, which gave links to other machines. The Principles of Science section had a plan setting rather like a museum with each item on a display panel, although items such as telecommunications/ inclined planes may need explaining to younger users. If the user selected Principles of Science from the machine section, the most appropriate links were offered. The History of Machines offered five main areas ranging from Antiquity through the Industrial Revolution to the Silicon Age, and selecting one area took the user into a timeline with several different inventions linked to the relevant period. Inventors listed each inventor and selecting a name took the user into a book metaphor with information on the inventor, their invention and links to the machine section. Other features included a back arrow facility, an index, options (printing and saving, and the mammoth movies) and help, which was context sensitive. The scientific content of each section of the package such as electricity was well constructed and linked theory to the actual objects to demonstrate how these work. The package had short animated (mammoth movie) sequences, which amusingly illustrated specific points.

8.7 Grolier's Encyclopaedia

The Grolier's Encyclopaedia main menu accessed the following topics: Title List, Knowledge Tree, Word Search, Pathmakers, Timelines, Knowledge Explorer, Multimedia Maps, Pictures, Sounds, Videos, Animations and Maps. Title List and Word Search features were similar, with the Title List requesting a name, but offering a list and Word Search simply requesting a name/subject to search for. Many topics have submenus, or, in Grolier's terms, subcategories, and these had a menu of selections. Knowledge Tree was similar with different groupings, which became more specific as the user moved down with subjects such as Arts, Society and Technology. The Pathmakers topic offered six options with subjects such as Innovators and Inventors, Great Thinkers and the Artist in the Modern Era.



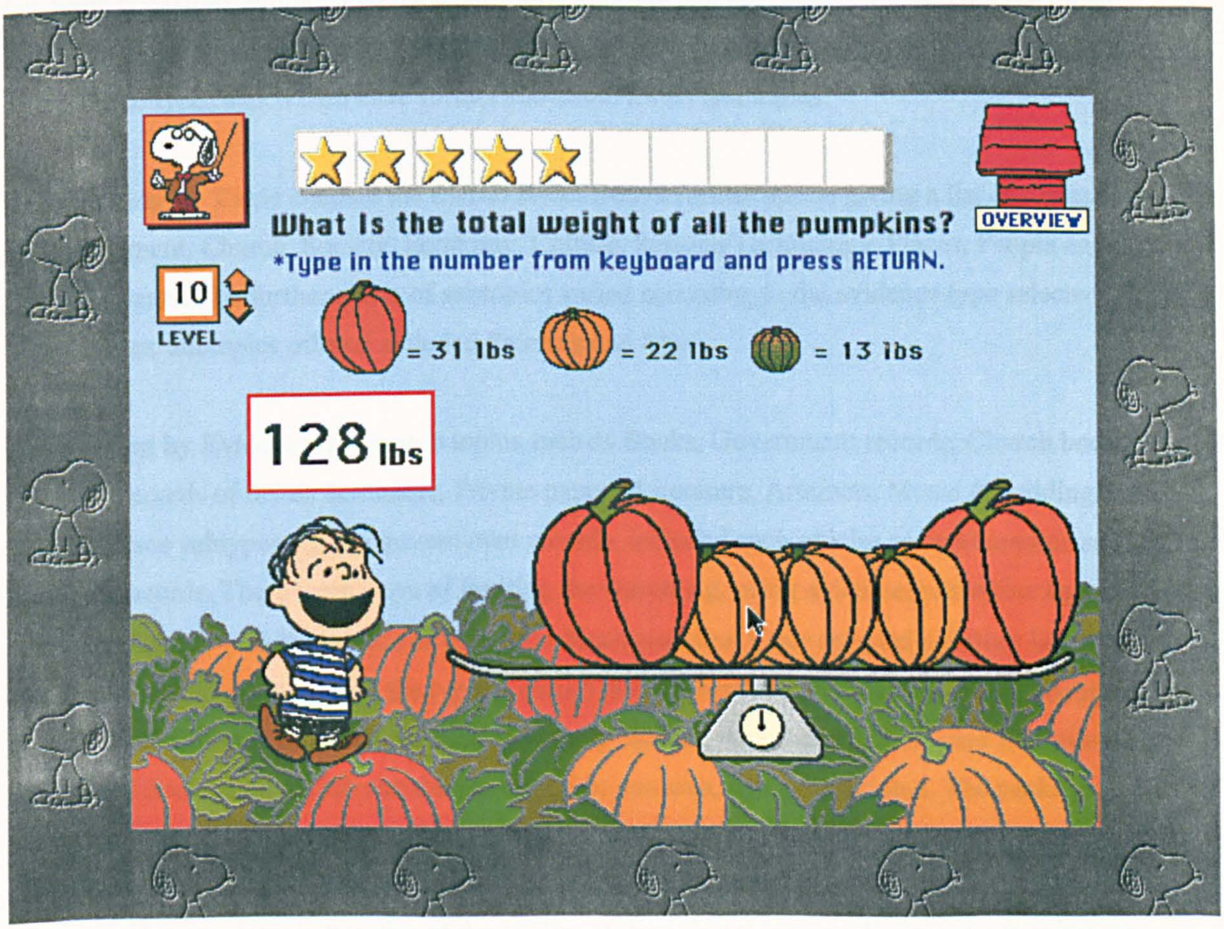


Fig 8.1 Main menu Screen of Peanuts, and below 8.2 Math Screen from Peanuts

Selecting one option brought up a list of people with video and audio recordings listed with the person. Timelines took the user to a timeline running from 100 million BC up to 1995 in a series of major periods. This was a conventional timeline with eight major thematic lines covering topics such as Egypt and the Stone Age. Knowledge Explorer also had a second menu with topics such as Science, History, The Arts and Nature, with a further menu, similar to the Knowledge Tree in format, i.e. a hierarchical approach, but containing video explorer essays, e.g. space exploration. Multimedia Maps covered items such as transportation and modern wars, with a second list and then an animated series of maps on the chosen topic. The Pictures option gave another submenu with major categories of plants and animals and media, and then listed the photographs available under each option. The Sounds option had another submenu and a list from which an item could be selected and the sound played. Videos, Animation and Maps had the same setup, with a submenu of topics and further contents under each topic, operated by clicking the selection or the video bar.

8.8 Medieval Realms

The Medieval Realms package was a large database of original source material for the period 1066 to 1500, with 1475 records of manuscripts, buildings, sites, artefacts, written text sources, music and spoken word recordings. Most of the older pairs were given this package, as their teacher had requested this. Other packages for each group were selected by the researcher based on the children's interests in the pretest, and to allow some use of each package across each age group. On some occasions pupils asked for a particular package and the request was usually complied with. There were two main ways (detailed below) of initially searching the database, by topic and by evidence type, which then have further sub menu levels and topics.

a) Searching by Topic enabled the user to select from a further option giving a list of topics such as Government, Church, Society, Economy, Culture, Science/Technology, Places, People and Special Events. The further series of subtopics varied according to the evidence type selected, e.g. from culture, subtopics offered included Painting and Music.

b) Selecting by Evidence Type with topics such as Books, Government records, Church books & records, Records of towns & manors, Private papers, Literature, Artefacts, Music &Building/Sites. The Evidence subtypes e.g. for government records, included such articles as legal records and financial records. There were ways of limiting the search e.g. using a date search; either by period or by key dates, by finding words or using combined searches. Once selected a further list of items was given with icons to display the type of record they represented and then the actual document was displayed. There were features such as tagging records, which enabled the user to create their own list of documents, which can then be stored in one area, copied or printed. The package had teacher's guides, investigations and suggested ways of using it. Medieval Realms was a very impressive resource and contained the sort of information that was most valuable for multimedia research. This was largely because of the quality of the original historic documents, forming the resource core, together with the graphics and music with a powerful but complex search facility.

The interface needs redesigning and rethinking especially for younger pupils, but the British Library is in the process of developing an improved interface for the software resource. Multimedia software that has been designed to navigate topics and subtopics has been used by Evans and Edwards (1999) in their interface of a Virtual module, which allowed the student flexibility as well as giving them an indication of their progress through the subject material, but did constrain their route. Development of this sort of structure would make the Medieval Realms package more user-friendly. The teachers' worksheets and resources need integrating into the main information source so they are accessible for teachers and pupils. The teachers' resource detailed research projects achievable within the resource, potential questions, ideas and research areas.

8.9 Eyewitness Guide to History

The Eyewitness Guide to History had a front page with a desk metaphor, with various options, which could be opened or looked at. These included drawers of each of the main periods; items of interest which change with the period selected and additional information such as a globe, help file and index. The user selected the major topic and then had various subtopics presented to them. On selecting one of these the user took a set route until the end of the topic was reached. Certain topics were linked into other areas and it was possible to follow one of these direct links. A quiz was also available which also allowed the user to go back into the package to find specific help to answer the question, and was intended as a guide to assessing the users' knowledge.

8.10 Selection of software for the second study

The most suitable multimedia packages that allowed the maximum number and types of navigation patterns were in the form of encyclopaedias. An encyclopaedic format was considered the most flexible in terms of navigational routes, to allow for many different ways of assessing information. Each encyclopaedia was assessed for its navigational patterns range and the greatest flexibility. This multiple access ability would allow forced navigational routes and investigate whether or not users would re-use the methods of navigating that they had been previously been forced to use.

Trumbull, Gay and Mazur (1992) used encyclopaedic format multimedia as they considered that this format supported free exploration and specific information enquiries. They stated that although tutorial style multimedia is based on interaction with a teacher it does not have a comparable provenance which makes design and navigation decisions more difficult. Although encyclopaedias may be considered by some researchers to be lacking in structure, they do conform to a known setup, and this can allow differences in navigation methods. The two most successful in terms of navigation routes and flexibility were Compton's and Encarta. Compton's enabled the user to start from a room filled with different objects and go through various paths to the information, such as a globe, books, maps, television, etc., while Encarta had several prescribed routes and great flexibility in its use. The resource pack for Encarta was valuable as it detailed ways of using the package for research, as well as giving templates and instructions to teachers on using the package and examples of its use. The selection of Encarta was made because it offered the most flexibility and information on how it should be used, as well as the greater number of potential alternative routes possible and the research capability to research an area in depth. Hence Encarta was selected as it had the greatest potential in terms of:

1. Possible navigational routes;
2. Extensive resource in terms of text, graphics, video, interactive tasks and teacher's pack;
3. Maximum flexibility in use.

The Encarta package allowed the design perspectives to be investigated as several design facilities were incorporated within the software, allowing them to select their personal preferences. It was also decided to examine the same package for the entire session. Changing the software might have provided greater variety for the user, but would entail another induction period to develop familiarity with the software, extending the time needed to make reasonable use of the package.

8.11 Analysis techniques

The type of interaction performed by the children in the browsing task was recognized and recorded by the observer taking notes and following screen-by-screen moves. The children's comments made in each software package inevitably varied with the type and nature of the package as well as the children's age and ability, together with their perception of the task. Each pair was given two software packages out of the list (cf. Table 9.2). The three tasks were explained in outline and then the first task was detailed – the browsing task. The pair was then observed and recorded. The second task was then performed and the same two tasks repeated for the second package. At the end of the sequence the third task was given for one software package. The post-test interview queried why certain routes were taken.

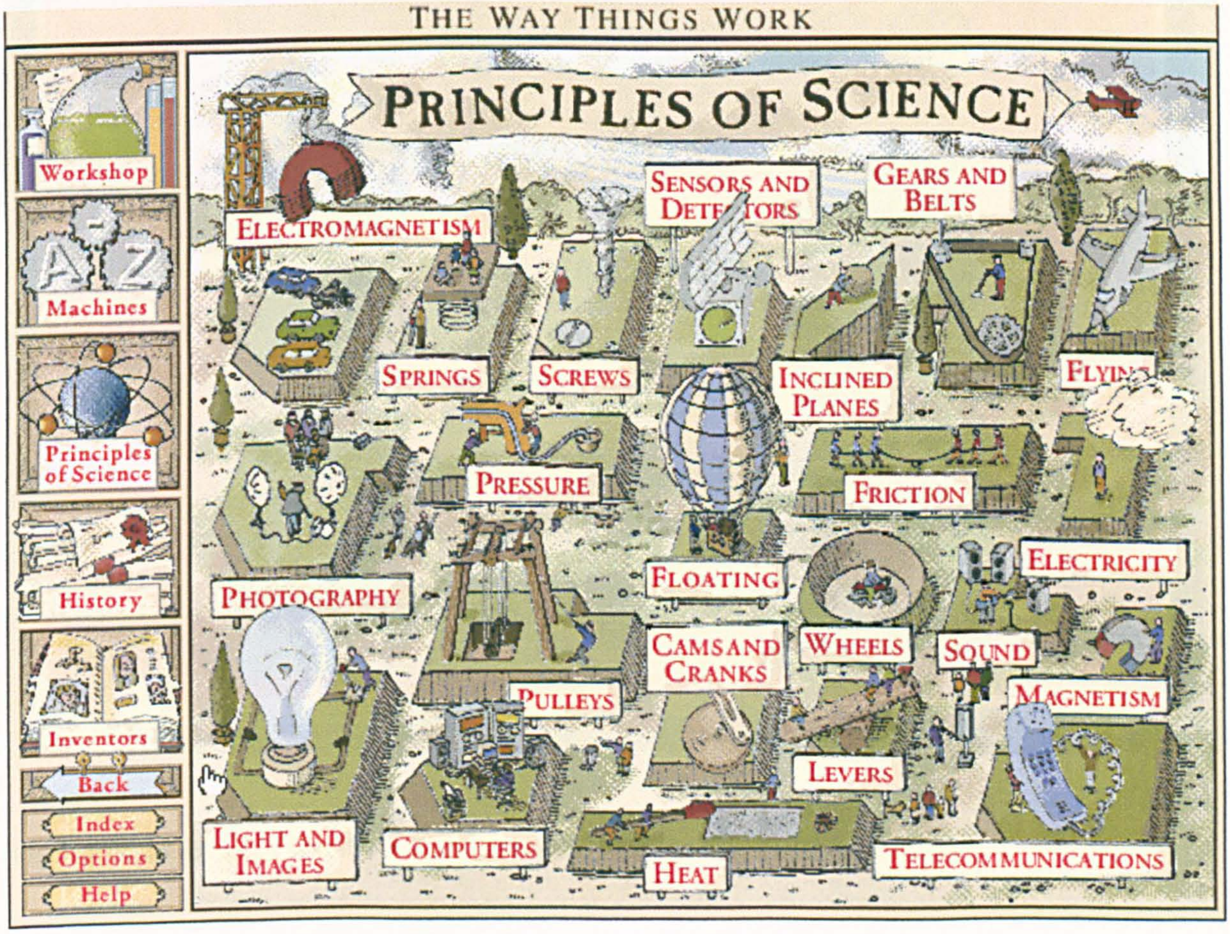


Fig 8.3 Main menu of The Way Things Work & Fig 8.4 Principles of Science

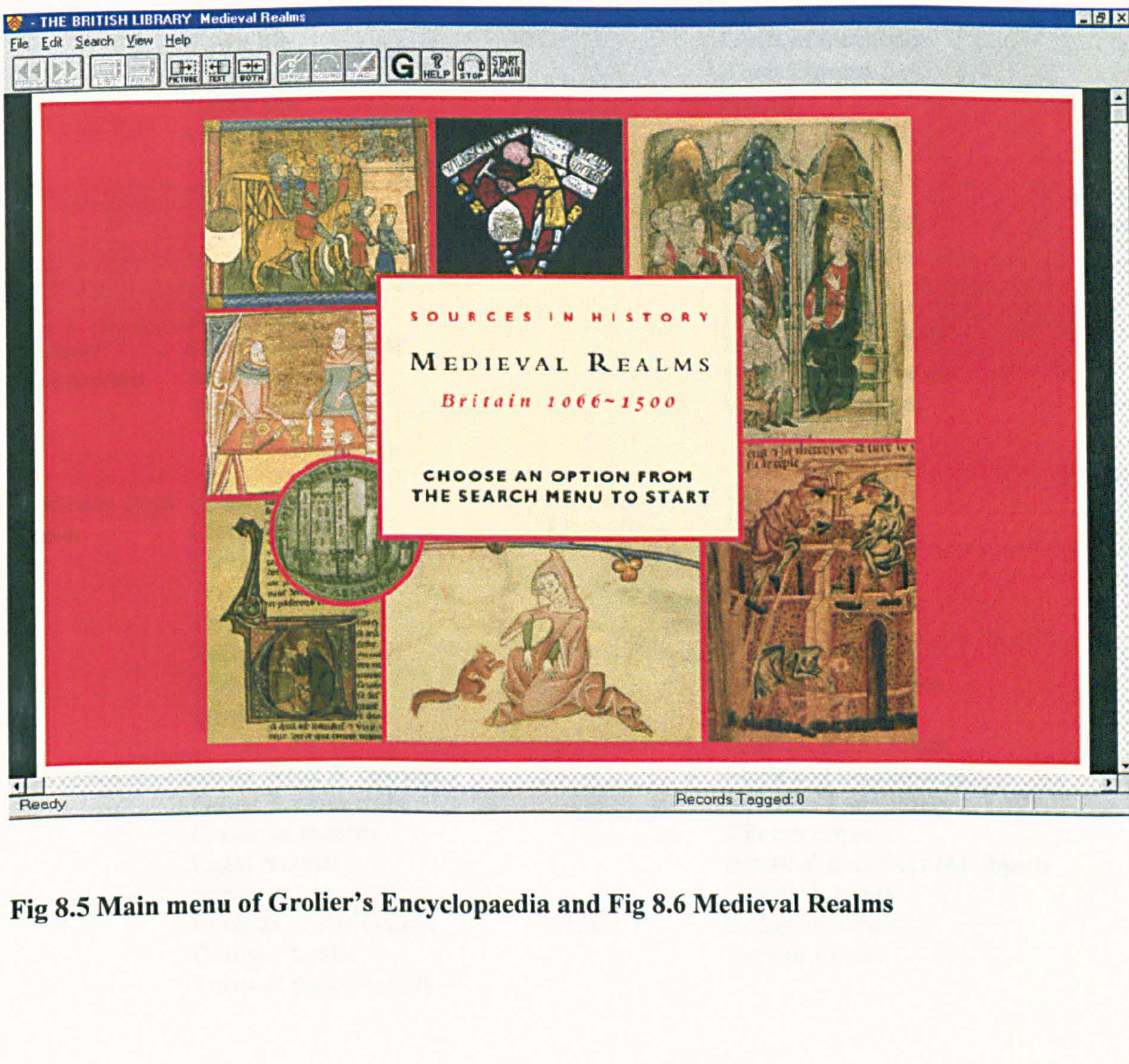


Fig 8.5 Main menu of Grolier's Encyclopaedia and Fig 8.6 Medieval Realms

Fig 8.7 Topics, Sub-topics and Evidence Types from Medieval Realms Britain 1066-1500

1) Topic List with subtopics 2) Evidence types

Topic	Subtopic
Government	Feudalism
	Monarchy
	Parliament
	Money
	Law/Justice
	Castles
	Towns
	Manors
	Forests
	War
Church	Christendom
	Islam
	Jews
	Pope
	Monks, nuns & friars
	Hermits & anchoresses
	Bishops
	Parishes
	Beliefs
	Pilgrimages
	Cathedral/buildings
Society	Court
	Tournaments
	Town life
	Village life
	Castle life
	Crime
	Food
	Dress
	Travel & transport
	Houses & home life
	Games, sports & pastimes
	Education
Science/ Technology	Disease & medicine
	Science & maths
	Tools & materials

Topic	Subtopic
Economy	Farming
	Crafts & Industry
	Merchants & Trade
	Guilds
	Wool trade
Culture	Music
	Architecture
	Stories & poems
	Painting
	Sculpture
	Heraldry
Places	Exploration
	The East
	Europe
	France
	England
	Ireland
	Scotland
	Wales
People	Villeins/peasants
	Knights & squires
	Lords of the manor
	Kings/Queens
	Barons
	Women
	Children
Special Events	Norman Conquest
	Magna Carta
	Crusades
	Peasant's Revolt
	Black Death
	Hundred Years War
	Wars of the Roses

Evidence type	Sub-type
Books	Chronicles
	Lives
	Travel writing
	Treatises
	Recipe books
	Maps
	Printed books
Government records	Writs & charters
	Patent & close rolls
	Financial records
	Legal records
	Inquiries
	Records of Parliament
	Coroner's rolls
	Town & guild records

Evidence type	Sub-type
Literature	Romances
	Drama
	Poetry
Artefacts	Seals
	Armour & weapons
	Coins
	Musical instruments
	Scientific instruments
	Textiles/ embroidery
	Church objects
	Personal & household objects
	Chests & boxes
Music	Religious music
	Secular music

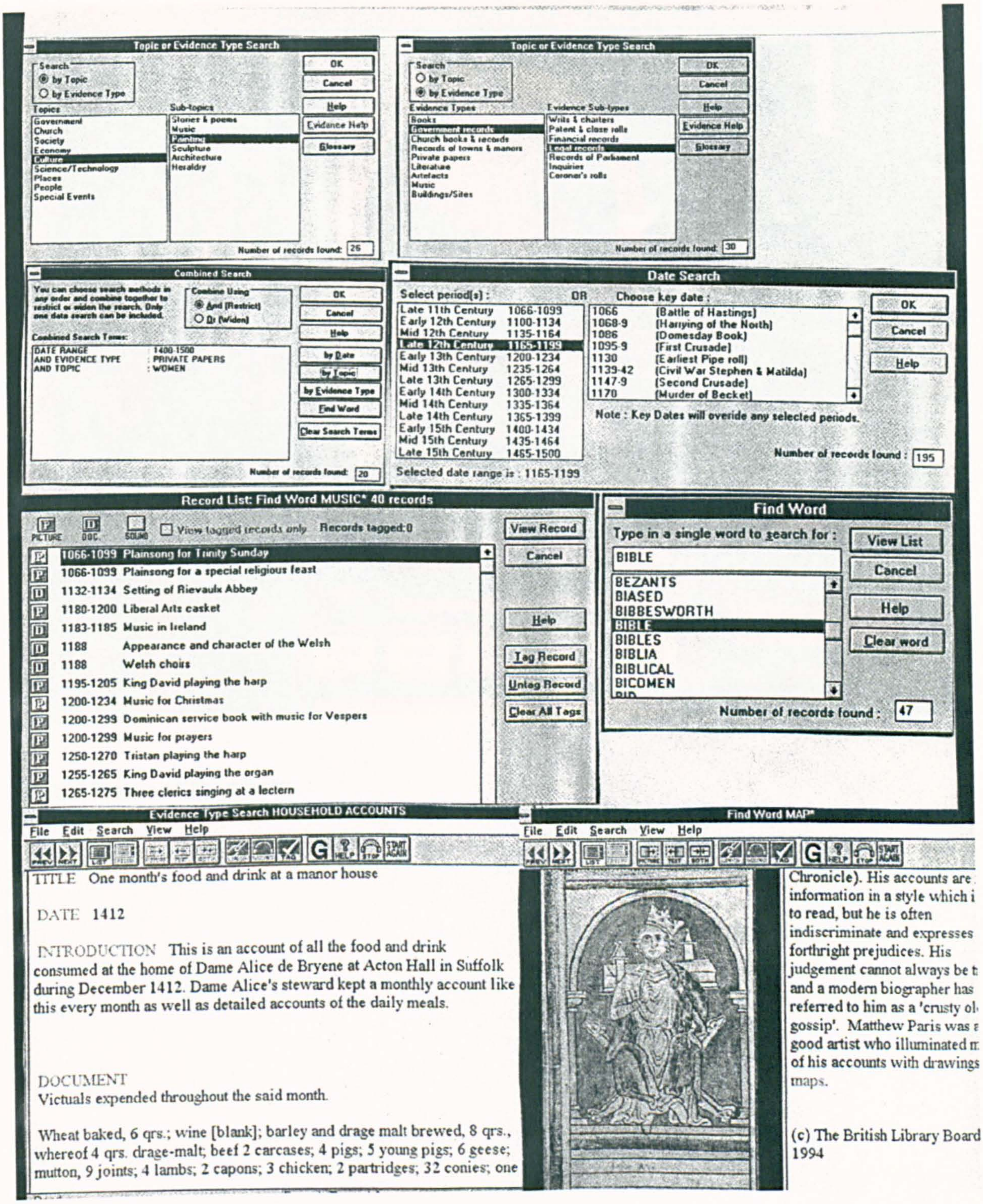


Fig 8.8 Searching in Medieval Realms, Searches by Topic /Evidence/ Combined

Fig 8.9 Screen of Eyewitness

Part II Methodology and Software

Part II Contents:

Part III
Study 1

Part III Contents:

9

Study 1

9.1 Introduction

This chapter details the results from the first empirical study. The aims of the first study were to assess whether users had distinct navigational pattern preferences, what these were and how they were used. The first study explored the designer perspective issues. The relationship between the software design and its analysis is the basis of the following two chapters on navigational patterns and working strategies, and the first study outcomes will inform the second study design.
The first study is intended to explore the following items:

- Firstly whether or not users have distinct navigational patterns and working strategies.
- Secondly if they have specific patterns, to develop a broad classification of these.
- Thirdly to test suitable software and suitable tasks, for further use in the second study.
- Fourthly to see if there were variations in how children and adults choose to navigate.

The first study was carried out in two Oxfordshire schools, which at the time had a three-tier system. The initial school used for the empirical study was a First School, for children aged 5 to 9. A small sample of children from Year 2 - Young group (aged 6/7) was observed first and then a larger sample of slightly older children in Year 3 - Middle Group (aged 7/8). The First School was in a socially mixed population area immediately east of central Oxford, with both working class and middle class children attending the school. The school had a fairly small catchment area and many of the children were local. Many parents helped in the school and there was an awareness of IT within the school community. The second school was a Middle School, with children aged from 9 to 13, pupils from the middle range, Year 7 - Older Group were observed (11-12 years old). The Middle School was situated in a predominately middle class and affluent part of North Oxford. The empirical work concentrated on the pupil's navigation, the areas used in each package, how they dealt with simple investigative tasks and how much help or advice was requested.

9.2 Procedure - First study empirical work

The first study involved older pairs of junior school pupils, in the last two years of the first school (aged 6/7 and 7/8 years) and pairs of secondary school children in the 11/12-year-old classes. In the first study pairs were selected, being the normal way that these users worked on the computer, and this enabled audio recordings to be made of the children's conversation. The class teachers selected the groups for the first study and these groups covered a range of ability across the whole sample. Each pair was to be of mixed gender and the teachers were asked to select pairs with similar ability levels. The two first school groups (aged 6/7 and 7/8) were selected to investigate if all children had distinct preferences or if this developed with their educational progression.

Table 9.1 First study pairs and their ability, experience and concentration levels

Group	Pair	Ability	Experience	Concentration
Young	O/S	H	L	M
Group	D/W	M/H	L	M
5 pairs	D/N	L	L	L
	T/B	L	L	L
	S/J	L/M	L	L
Middle	O/Q	H	M	H
Group	B/H	M	M	M
10 pairs	O/B	M/H	M	L/M
	B/B	L/M	L/M	L/M
	D/O	H	H	H
	S/H	M/H	L	M/H
	U/U	H	H	H
	H/H	M/H	L	M
	D/F	H	H	H
	I/T	L/M	M	L
Older	N/A	H/M	M	L/M
Group	T/S	L/M	H	M
8 pairs	U/T	H/M	L/M	M
	S/O	L/M	M	L
	D/H	M/H	H	M/H
	X/G	L/M	M/H	M
	B/J	H	H	H
	M/D	M/H	H	H

L - Low, M - Middle, H – High

The secondary children were selected as they had already been using multimedia, were older and more used to working with computers and their teachers were particularly keen to develop structured work with multimedia. In Table 9.1 the first study pairs are listed with their ability, experience and concentration levels assessed with the teacher. These categories were classified as L for Low, M for Middle and H for High. In cases where there was a difference within the pair, these classifications were given as a range e.g. L/M. In Table 9.2 (p.100), this information is linked to the software packages used by the pair.

9.3 User Interviews

Each user was asked to complete a pretest questionnaire. The sessions were then conducted with the user(s). Interviews were held after each of the multimedia sessions. The questions used in the pretest and interview sessions are in Appendix 1. In both the first and the second study a semi-structured format was used. The user was given a copy of the questions and these were worked through systematically, although the areas that were concentrated on and developed varied with the user. This was considered to be informative for the research, as this would allow specific areas or skills, abilities or problems to be investigated for each user, and it would have been difficult to predict these areas in advance. Hence the semi-structured technique allowed the same questions to be asked but for different follow-up questions allowing themes from the multimedia sessions to be explored and explained. The first study interview covered general multimedia questions, specific questions on the actual packages and their usage, and any problems that they had encountered.

9.4 Groups for the first study

There were 23 pairs in the first survey, as below:

Younger group - 5 pairs, consisting of 2 pairs aged 6/7 and 3 lower ability pairs aged 7/8

Middle group - aged 7/8 - 10 pairs, consisting of mostly middle to high ability pairs

Older/Secondary group - aged 11/12 - 8 pairs, consisting of pairs with a range of ability levels

Each pair was given arbitrary codes, so that the results were not attributable to specific individuals.

9.5 Research methods for the first study

The methods adopted for the first study have been detailed in the previous chapter and are only briefly described here. The pairs were given a pretest questionnaire and then observed using either two or three software packages, and the pairs' verbal interaction together was audio recorded. The users were asked to do three specific tasks and were interviewed afterwards, with questions covering their views on the packages and how they had approached them. The pretest questionnaire was given at the beginning of the multimedia session by the researcher (myself).

9.6 Results from the Pre-test questionnaire

The results from the pretest questionnaires showed variance in the amount and nature of the pupil's home computing, their preferences and hobbies and which television programmes they watched. They all showed a positive interest in computers, which meant that all the children wanted to do the tasks and were well motivated and all reasonably capable, except for the youngest group. This group aged between six and seven was not used to computers, expected a lot of help and had problems using multimedia on their own. Because of these factors and the biased effect that the amount of help and control needed from the researcher caused, only two pairs of this age group were included in the first study, the rest being 7/8 years old. The empirical work therefore concentrated on the older pupils (in age groups 7 to 8, and 11 to 12) who were more capable of independent work. The children's hobbies and interests were variable although most included sport. The younger children enjoyed a wide range of children's television programmes, while the secondary users preferred adult programmes, often including science fiction, films, and drama. The children were asked questions on their areas of interest in order to match any subject preferences with the tasks as well as linking areas of prior knowledge to their free choice options. Most of the children had a home computer or a games machine, and most were PC based, but some pairs did not know if their home computers had multimedia capabilities. Many children were not aware of what software was on their machines, except for the games software. They all said they had good levels of expertise. More older children had used multimedia than the younger ones, who usually needed an explanation of multimedia.

9.7 Using the Peanuts package

The majority of the children chose the maths option initially. They then selected the easy or hard option and worked through the problems, achieving stars for each correct answer. The geography puzzle was difficult for younger children, despite the apparently young interface design. The third task on layout was difficult for the younger children, for whom this software was intended and most of them considered the layout to be sequential and linear. This package was used by the very young group (aged 6 - 7), who enjoyed it, but it was very noisy and included a lot of music and cheering. The two pairs in this young group liked the point scoring and being given stars for correct answers and would usually have several attempts at a question. The two levels, easy and hard, were both relatively simple in mathematics but became progressively more difficult in geography. However the younger children were most unfamiliar with areas within Europe and this meant that the subject matter was more suitable for older children despite the fact the interface was designed for young children. Older primary children, apart from the lower ability children, were not keen on this interface and became bored quickly. One pair kept going rapidly through the math until they had finished all the available sums in a section to obtain the maximum number of stars.

9.8 Using the Way Things Work package

Effective features were the well thought out links to the particular inventors or associated machines and to the Principles of Science. There were two problem areas with the package. Firstly it was sometimes necessary to go back to the front menu to get the full index for each section; as only objects related to the last selection were given. Secondly the large number of menus within the package were distracting and presented problems for younger children. The menus offered different levels of selection and allowed greater depth and further options. However for the novice user they were confusing, especially when repeated, and the users were not necessarily aware of why they needed to keep selecting options. Older and more experienced users did not find this difficult, but younger users had less comprehension of the choices and even how the menu system worked. The tasks for the Way Things Work package were a browsing task for a set time, most of which was spent in the Workshop, and the selection and use of a topic the pupils themselves were interested in. The third layout task was the hardest task and proved difficult for most of the pairs. Despite the individual icons on the main menu and the thematic presentation of the individual subjects, the children, especially the younger ones, had difficulty visualising the software structure.

Although the themes were evident from the interface there were numerous links across these while using the package. These links may have camouflaged the essentially hierarchical nature of the package's structure, and making the structure appear more complicated than was actually the case. This package was well liked by the younger and middle school pairs as well as some older middle school pairs, although most considered the design of the interface (a sketch of a workshop), meant it was designed for younger children. The Workshop area with tools, animated objects and noises had variable appeal some pairs were rapidly bored while others frequently returned to it. The workshop area and the children's delight in it, proved to be a real problem in its design and it must be possible to limit the amount of time spent on the Workshop. This would have encouraged the children to use the package more constructively and to restrict the less productive but more fun aspects of the package, which could have rewarded children on completion of specific sections. This preference for the Workshop screen was particularly noticeable with lower ability children. The higher ability children became bored when they had tested the workshop components. Despite allowing the development of mouse control and confidence building with novice users, the noises were disruptive for other children not using the computer, if it was used in a general classroom setting. Other sections of the package were difficult for younger children as they needed to select areas of science or the inventor and these features both required reading and comprehension. The middle group of children fully investigated all sections, and followed these through to other areas such as the inventors. They felt that they learnt a lot from it, while the third group- secondary (Middle school) children found it a good source for information and liked the explanations, but they still found the younger interface a barrier, with some disliking the cartoon image.

9.9 Using Grolier's Encyclopaedia

The first task, the browsing task was used to look at a broad spectrum of different features of the package, although videos, pictures and animations were the preferred choices. The second task, selecting a topic within the encyclopaedia and following it through, proved more difficult and would often re-use items discovered in the browsing task. The layout task again proved difficult for the middle group but more manageable for the older children, who perceived the package as having many hierarchical links. The package was not designed for systematically working through each section, as there was a lot of repetition of features and many submenus. Users were expected to be selective, which was more difficult for younger users who may not always have understood the names of each section. There was a tendency for the younger users to prefer what was the most familiar and obvious from the titles, such as videos, pictures and animations and this meant that they concentrated on these areas. This encyclopaedia was difficult for the youngest groups to use, as they needed a lot of help and were not interested in the content. The middle age groups were more involved in it, and tried out most sections, but preferred certain areas, e.g. videos, animations and pictures. Some pairs, especially older ones were selective, but few had any search strategies.

Older children also moved more rapidly between sections, were more competent users, and frequently followed themes. One pair initially chose word search, but then had problems when a 'word to search for' was requested, as they had expected a selection list to choose from, as with other choices in the package. The browsing task was perhaps an unnatural use of an encyclopaedia, as the student would normally have had a specific need to use the encyclopaedia before going into it. In this package, prior knowledge was also an essential decider of what each pair looked at initially in the browsing task. A few pairs, especially the middle group, were easily bored and wanted to change to a different package, after only a short time. The hierarchical system was confusing for totally novice children who opened multiple windows and needed to close them before progressing. There was no easy return feature, i.e. a method of returning immediately up the tree, instead the user had to return the way they had come. Some sections within the encyclopaedia had large text areas. Graphics were not always well integrated e.g. videos were in a separate section rather than linked to the subject area, which proved difficult for the younger and middle group but was acceptable for secondary school and adult users.

9.10 Using Medieval Realms

The tasks for Medieval Realms consisted of 1) an initial browsing task for users to familiarise themselves with the package, 2) a specific fact finding exercise, usually a set subject (although there was some choice) and finally 3) a layout question. The latter layout task proved the most difficult, and many pairs preferred analysing the layout of the other package they had used, as Realms was the more complex of the two multimedia resources they had used. Two middle group pairs allocated Medieval Realms found it hard to use. The complex search methods and detailed package content was more suited to the Middle School group (aged 11/12) especially as it linked with their Humanities project work. The browsing task frequently meant they selected what they had recently dealt with such as castles, or the Bayeux tapestry. This project work affected what searches the pupils performed, as they used prior knowledge and looked at subjects they had covered in school, and many groups selected the same items. The hierarchical system took time to get used to and use successfully with its menus and subtopics, as did the complicated list and tagging methods. Six older group pairs who used the package disliked the interface but enjoyed the actual documents; especially liking the pictorial information, the music and items they had already seen (like the Bayeux tapestry) or referred to in History lessons. Three pairs were very involved with this package and wanted to continue using it, and were impressed with the real documents.

9.11 Using Eyewitness Guide to History

The pairs used the browsing task constructively, looking at several sections of the package. The task of finding specific information was also performed well, with the pairs selecting a particular period and following it through until the end of the task. The three pairs using this package all succeeded in producing an outline layout. The secondary group on the whole preferred this to Medieval Realms mostly because of the iterative, easy to use interface. This mixed an encyclopaedic approach with a games interface and was intriguing to the user. Motivation is a key issue with school age children and the Eyewitness package succeeded in developing the student's interest by combining a pictorial interface with small quantities of historical facts. This interface was designed for specific age groups as older secondary pupils found the information available restrictive, as when they became interested in knowing more about the subject the item ended. The analysis of the children's behaviour when using these interfaces should be able to inform design practice. A compromise between a very detailed text based search strategy and a pictorial selection method produced different behaviour. The simpler interface encouraged more investigation whereas the text-based interface deterred even very informed and high ability pupils. The children considered this package engaging and informative (although there were comments on the lack of depth) and especially liked different ways of getting into the information.

Each group had a different approach and looked at different things, even in the same historical period. The design of the package did not make any particular aspect of each of the historical periods more vital than all the others: they were all equally important. Although there were good links to other information, some users found the amount of information superficial. Where they became involved in a particular subject, they rapidly covered the whole subject and finished. This awareness of the lack of depth in the information also happened in the task work. The biggest drawback of the package was the quiz, which was totally addictive. These devices could be used as a form of designed-in strategy if the package designers were aware of these addictive qualities, and use this for educational purposes. This could be done by restricting the number of guesses and then forcing consultation of the resource for the correct information. The concern with navigational patterns research here is that the quiz's attraction clearly over-rides what children might bring to the session and to a certain extent the experience they gain from it. This use of designed in strategies has been detailed in Part I (cf. 3.13). Two pairs discovered the quiz early on in their exploration of the package, and remained in it, going through it repeatedly, and usually guessing the answers. Few pairs used the available facility to go into the package to find out information, allowing them to answer the quiz accurately.

Controlling the use of the quiz, or even making it the base for a search strategy, would be essential if pupils used the package on their own. However the package was good for novices or those unfamiliar with a particular subject as it gave them a quick and concise introduction. The secondary age group enjoyed Eyewitness History, but these older pupils, although they liked the overview, were perceptive enough to find the limited information available frustrating. There was a little use of a historical sequence, but as it was divided into preset historical sections, the whole package could be investigated fairly quickly. Analysing the screen-by-screen movements enabled a list of each pair's screen visits to be compiled and to be checked against the pretest interviews. The timings and the amount of time the pair spent on each screen as well as who was in control of the mouse and therefore navigating was also recorded. It was possible to create an interpretation of how each of the two users worked together and to some extent their own preferences, as some users returned to where they had left off on their turn. These routes were analysed for particular paths through the software to give an indication of the type of pattern used. Some of the patterns were very obvious from the movement through the software. This was evident where the pupil continued to follow a specific sequential route, i.e. visiting all nodes on a linear route or all the component parts of a circular route on one level of the package. Hierarchical routes were straightforward to follow as the user continued down until they reached the bottom of the available information. The comments on the lack of depth (e.g. with Eyewitness) occurred when the user reached the end of the available information earlier than they had expected or wished to. In the larger databases the user would frequently finish the search before every possible item had been interrogated. This continuation of a specific pattern allowed the user to be assigned with this pattern type as one of their favourites. With some pairs there was a noticeable difference between (and change in the pattern) between each pair member.

9.12 Interaction example

An interaction from one pair (older, secondary pair identified as M/D) is included in outline form.

Medieval Realms

Topic/ Evidence – Culture – Architecture

Stone carving - List to Stone carving of lion – Brough Castle (Image)

Santiago de Compestelo then Bury St Edmunds

New search - Position of Women – Status- Land – Position

Welsh princess beaten in battle

Heroic death of a woman crusader to Independent women – Halesown

(Given task to draw structure) Search by Evidence type – checked component parts

Eyewitness Guide

Age of Great Religion

1600 (chosen) to Quizmaster – 2 players – several questions

Continued using quiz master then (Task to investigate specific subject)

All aspects - Up to 500 BC - Tutankhamen – Carter to / Egypt of the Pharoahs

See also – Famous places – Key Facts – Chose Famous Pharoahs - Read Famous Pharoahs section

See also – Life in Ancient Egypt – Followed links until exhausted all section (Interview)

9.13 First study pairs and the software used

Table 9.2 (overleaf) lists the code for each pair and the software, with the first study's five packages listed with each pair's usage. Most pairs used two packages, but four pairs used three packages, for three reasons: they did not progress, became disinterested or the package was at the wrong level.

9.14 First study Navigational patterns - Overview of Young group

The younger age group found it difficult to use multimedia, as they needed co-ordination and manual mouse dexterity, and had problems in navigation. Most multimedia packages assume an ability to read, even for navigating, and a high level reading skills. This age group's severe problems with navigation meant they needed adult help/ direction frequently; they were not used to computer work on their own and needed to be told what to do. It may have been unusual for the pupils to have free time or to do what they wanted, but they had few self-study or learning skills. They found the tasks difficult and often failed to complete them, suggesting they needed specific and closed tasks, with a definite end. Three pairs of older, less able children were classified with this younger group, due to their low ability, lack of concentration (e.g. became bored easily and had a lack of interest in their pair's search) and high requirements for help. They were not interested in working as pairs and were easily distracted, and needed to be supervised when using multimedia. The teacher was aware of the need for help for this group and considered there would be less benefit from using multimedia unless they had an adult to help them, as they were unfamiliar with it, and were unused to working in this way. In fact the problems this age group experienced and their guidance needs meant the first study concentrated on the two older groups.

Table 9.2 First study pairs, their ability levels and the software

Pairs	Ability	Experi-ence	Concent-ration	WTW	GME	MR	Pea Nuts	Eye Witness
Young Group								
O/S	H	L	M	√	√		√	
D/W	M/H	L	M	√			√	
D/N	L	L	L	√	√			
T/B	L	L	L	√	√			
S/J	L/M	L	L	√	√			
5 pairs				**5**	**4**	**0**	**2**	**0**
Middle Group								
O/Q	H	M	H	√	√			
B/H	M	M	M	√	√			
O/B	M/H	M	L/M	√	√			
B/B	L/M	L/M	L/M	√	√			
D/O	H	H	H	√	√			
S/H	M/H	L	M/H	√	√			
U/U	H	H	H	√	√	√		
H/H	M/H	L	M		√	√	√	
D/F	H	H	H	√	√			
I/T	L/M	M	L	√	√			
10 pairs				**9**	**10**	**2**	**1**	**0**
Older Group								
N/A	H/M	M	L/M			√		√
T/S	L/M	H	M			√		√
U/T	H/M	L/M	M	√		√		
S/O	L/M	M	L	√				√
D/H	M/H	H	H/M		√		√	√
X/G	L/M	M/H	M	√	√	√		
B/J	H	H	H	√		√		
M/D	M/H	H	H	√	√	√		
8 pairs				**5**	**3**	**6**	**1**	**4**
			Totals	**19**	**17**	**8**	**4**	**4**

WTW- Way Things Work, GME – Grolier's Multimedia, MR - Medieval Realms, PeaNuts-Peanuts

The help needed meant they were not doing the tasks as envisaged, and the amount of assistance required, especially in knowing where and how to navigate through the package compromised the navigation patterns they used. Needing more help and direction from the researcher meant it was difficult to determine which navigation patterns they preferred, additionally difficulties in reading and comprehending the content meant that they needed fulltime adult help in completing the tasks. This small sample was valuable as it determined the level for assessing individual preferences. The younger age group was slow, did little text reading on the screen and the most common navigational pattern was linear. Some pairs went down into the next layer of information and created a star pattern, but even this pattern was short-lived and erratic. Two pairs (out of 5 - the high ability younger pair and the low/middle ability pair) used hierarchical searching with more depth in a search, although these were short searches, while the lower ability pair and the very young middle/high ability pair continued with the linear pattern.

This suggested that higher ability children carried out more involved searches, but the sample was too small to develop this idea. Their navigating confidence and their mouse control were different, and both factors affected navigation. Another way of analysing this material would have been to look at what the users were doing when they used different patterns, and what factors affected how systematic these patterns were, how long lived and the user's choices. The information on the patterns used and the reasons for selecting routes was collected and the subsequent patterns analysed from the observational records. A prohibiting factor in analyses of this kind was that children often did not comment on why they had chosen particular patterns or routes, even when questioned. Certain kinds of pattern usage should reflect their preferences in searching for information, e.g. a star pattern involves the user going down a level in the resource and returning up a level before continuing, and the circular pattern, when complete, involves the user going to most main points on a level until all are visited.

9.15 Overview of Middle group (Aged 7-8, 10 pairs of middle to high ability aged 7/8)

The middle group liked using multimedia, was keen and motivated and multimedia was new to them. Some pupils were competent but the amount and nature of their abilities and skills were variable. Questions and problems with this group were about navigation, with some software comments. Most pairs were reluctant to stop at the end of the session, although one pair became bored very quickly and asked to stop. The mixed pairs worked well, as did all female pairs, while the male pairs tended to be lively, sometimes misbehaving. Some pairs were aware of the tape recorder, but most talked into it and became less aware through time. There was some negotiation over turns and sharing the task, some willingly sharing, while others disputed this and worked out a solution. There was less deferential behaviour than with the older pupils and there were fewer gender-related issues.

The middle group all used a linear pattern at some stage during their multimedia session. Out of the ten pairs, six went down into slightly more depth, on a star pattern. Most of these pupils also used a hierarchical pattern to investigate particular subjects. The hierarchical pattern was the second most popular after the linear pattern and reveals more sophistication as it enables a deeper search, which was rare with the younger group. Most middle group pairs used browsing as a main means of searching and the trial and error method appeared to be preferred by this group. Significantly it was the middle to higher ability pupils that investigated the use of other patterns and strategies and not just those they had used earlier. These pupils had greater experience in using multimedia and computers generally, which may explain their willingness to try other methods. Gender differences caused difficulties, as boys were domineering and wanted control of the mouse, and positioned themselves next to it. Some mixed sex and different abilities pairs' behaviour was deferential to the other pair member.

9.16 Overview of Older group (Secondary pupils, 8 pairs of mixed ability aged 11-12)

The secondary school pupils were competent users, as most pupils had used multimedia at home or in school. This group was very task orientated and disliked browsing, but this could be explained by their teacher's usual teaching method, which was to give a task to complete in a set time. This educational method meant that they were unused and unwilling to spend the time trying to find unspecific information. Their tasks normally had a set time limit and they were very conscious of the time. The school usually imposed time limits on computer work, because of the limited resource and/or the lesson changing. In addition the staff member and frequently pupils' location changed. All of this age group preferred to be given a task and complete it, with very little browsing, but time was spent orientating themselves, exceptions were the low ability pairs who were content to browse, which could be explained by this group being less task (and grade) driven. Skill levels were good, pupils had reasonable co-ordination and fewer mouse problems. These pupils needed less help with navigation. Pairs preferred not to ask for help, but to resolve problems themselves, being used to problem solving and pair working. The pupils were business like: they liked to get down to it, finish the task, and continue with the session.

The mixed pairs within the secondary group were deferential to each other, possibly explained by their not being in their normal groups. Single sex pairs worked better together as they were co-operative and less polite than mixed pairs. The best pairs for working were friendship pairs, but these pairs were difficult to observe, as they talked less but had more nonverbal communication. Conversation between the pairs was kept to a minimum and some pairs were aware of the recording, resulting in pointing at the screen, and making quick comments, which was noticeable with single sex groups, especially friends. Additionally background noise (e.g. lesson changes) affected the audio recordings quality. In the older/secondary group all the pupils used multiple navigation patterns, the majority of the pupils used a linear pattern and all of them used a hierarchical one. A few older pupils used the star or circular pattern. The choice of navigation patterns was due to personal preferences, but they were all prepared to try alternative methods. With reference to their use of working strategies most of the pupils remained with a general browsing method, but also used trial and error and some more thoughtful examination to move through the packages. These groups spent more frequent and longer time periods using different working strategies, with some in depth or ordered investigation, although this was still restricted. The experienced pupils as well as those with higher ability used more varied strategies than less experienced and less able pupils.

9.17 General comments on navigational patterns

The detailed discussion of the navigational patterns used in the first study and a classification is included in Chapter 10, while links between the navigation patterns of all the groups and with working strategies is in Chapter 11. The navigational methods used by the pupils showed a great deal of variation. Explanations for this are: the advice given to the pupils, prior knowledge of the subject area, of multimedia or the specific package, or even the presence of the observer.

Previous experience of computers or games affected the navigation methods used, and there were links between experience and navigation methods (Table 9.3 overleaf). The navigational patterns used demonstrated clear linear preferences, as specific users (three pairs) always followed a linear path e.g. by using the Index, Glossary, or Time line. Other users were very graphically orientated and would find an image they liked or recognised and follow these. There were users who wanted to cover every section, and then commented that they had completed everything. One of the problems with having pairs was that this camouflaged the individual's preferences, and in the majority of cases a compromise navigational route was achieved. The actual navigational patterns produced by the pairs in the first study were an amalgamation of the two individual's routes. However it was significant that in two cases where a compromise was not reached, (i.e. they worked as two individuals, returning to their own preferred navigational route each turn); there were differences within the pair. This inability to compromise would prove more difficult if the pupils were placed in larger groups, which can occur in primary schools.

The fact that pupils wanted to select and continue on their own route regardless of their partner was a significant finding, and meant that individuals rather than pairs were selected for the second study. Some pairs operated as two individuals with one being uninterested in the other's route, and only becoming involved on their turn, while others worked together and determined where they would navigate together. This latter behaviour was normal for the older group. The behaviour where two individuals worked as a pair was more noticeable in the middle group, especially if there were differences in ability or experience within the pair. Two instances occurred where one of the pair returned to their known and tested methods (in both cases a linear method) and used certain preferred tools, such as the index, using these tools to the exclusion of all others. The technique of rapid clicking was still a phenomenon, especially with younger and middle groups, who were less experienced, but rare with secondary children and adults. Pupils were given an introduction to each package and task.

9.18 Working strategies results

The working strategies used in the first study are discussed in Chapter 11, where these are related to the navigational patterns discussion (Chapter 10). The first study working strategies were basic. All the groups spent most of their time on simple browsing or orientation strategies and using trial and error techniques, rather than using distinct, recognisible working strategies. Specific working strategies were used by certain pairs, although their use was infrequent, and only occurred with the higher ability and experience groups. The fact that working strategies could be recognised by these groups was a significant distinction (cf. second study) as it proved that it would be possible to differentiate between navigation patterns and working strategies. Three adult users were included in the first study in order to compare adults with younger pupils. The rationale for including this small adult group has been discussed in the methodology chapter. However the second study concentrated on adults, and the first study centred on children, to determine if they had any preferred navigational patterns. Two observations were conducted, of a pair and an individual.

The pair had multimedia experience and high levels of computing and task awareness, whereas the individual had some computer experience but little multimedia experience. Both adult sets were keen to learn more about multimedia and wanted to do the tasks.

Table 9.3 Navigation Patterns from Study I with Ability/ Experience/ Concentration

Pairs	Abil	Exper	Conc	Linear NP	Circul NP	Star NP	Hier NP	Com NP	Brows WS	Other WS
O/S	H	L	M	√			√			√
D/X	H/M	L	M	√		√			√	
D/N	L	L	L	√	√				√	
T/B	L	L	L	√	√				√	
S/J	M/L	L	L	√			√		√	
O/Q	H	M	H	√	√		√		√	√
B/H	M	M	M	√			√		√	
O/B	M/H	M	M/L	√		√	√		√	√
B/B	L/M	L/M	L/M	√		√			√	
D/O	H	H	H	√			√		√	√
S/H	M/H	L	M/H	√		√	√			√
U/U	H	H	H	√		√	√		√	√
H/H	M/H	L	M	√			√		√	
D/F	H	H	H	√		√	√		√	
I/T	L/M	M	L			√			√	
N/A	H/M	M	M/L	√	√		√		√	√
T/S	M/L	H	M	√			√		√	
U/T	H/M	L/M	M		√		√		√	
S/O	M/L	M	L	√	√		√		√	
D/H	M/H	H	H/M	√			√		√	√
X/G	L/M	M/H	M	√	√		√		√	
B/J	H	H	H	√			√		√	√
M/D	M/H	H	H	√		√	√		√	√
23 Pairs				21	7	8	18	0	21	10

L /Low, M /Middle, H/High, Abil /Ability, Exp/Experience, Conc/Concentration, Circ/Circular, Hier/Hierarchical, Com/Complex, Brows/Browsing NP/Navigational Pattern WS/Working st.

The experienced adult pair made several constructive comments on the software, such as questioning why the package (Medieval Realms) was not fully developed and that it appeared as an emergent rather than a finished product. They suggested more links; and activities and search methods should be incorporated.

The adults used prior knowledge to determine what they started looking at, which was not done by younger pupils. They worked out the package structure quickly and were aware of their location, repeated sections, completed routes and returned to menus.

The adult pair remained in the same package all through the session and investigated it thoroughly using largely hierarchical patterns, but this was probably related to the structure of the package. However as they kept returning to various points and going back over the information they had a complex but structured route. The use of a complex structure was unusual in the first study and most of the other group's patterns could be classified as linear, circular, hierarchical or star patterns. The individual adult wanted to view the packages that the younger pupils had used, as well as complete the tasks. The individual subject used two of the packages that the younger pupils had used: The Way Things Work and Grolier's Encyclopaedia. She used a hierarchical pattern in the navigation, finding topics that she was interested in and investigating them to some depth. She concentrated on particular areas, especially the second package and on one long, in depth search. Significantly, her layout suggested a complex structure with interlinking between all the different sections of the package. The two adult groups were a small sample and as the second study was concerned with adults, these adult users were useful in outlining differences between the groups.

9.19 Tasks discussion - Findings from the first browsing task

The tasks have been detailed in the methodology chapter and a resume is included before the discussion of the tasks findings. The browsing task was used for orientation and involved looking at aspects of each package, some pairs being thorough, while others were restrictive. Surprisingly the middle group was the most adventurous and appeared to discover more of each multimedia package. The secondary group was more ordered and systematic but this meant they would follow a particular path through the software rather than exploring options. The secondary group disliked browsing, and considered it a waste of time, a view shared by two middle pairs. In contrast the other eight middle group pairs liked browsing, but some pairs found it difficult to stop browsing and complete tasks, preferring to investigate topics that interested them.

9.20 Findings from the second navigating task

The second task was to select a particular topic and to find out about it. Most groups selected their own topic, if they had problems deciding or if they asked directly, a subject was suggested. Frequently they returned to a subject they already knew about, or to something covered in the browsing session. Some groups wanted a specific task to do and created their own specific task. This method seemed a more usual way for them to work and these groups were more enthusiastic and usually more productive while doing these set tasks. Some pairs were very pedantic, e.g. they insisted on following certain paths, while others were more adventurous or ordered. Others, especially the younger ones, followed random paths and appeared to be guessing where to go. Two pairs thought there was one best route or that they were expected to follow a set path and had to find it, which probably reflected their normal work pattern.

These pairs checked if they had got it right and asked for help to progress further. These particular pairs were concerned with how other children had performed, were competitive and wanted to know if they were better or the same as others. There were definite route preferences, with pairs following linear paths, or returning to familiar tools e.g. index or the glossary. No pairs used their best navigational skills in packages such as Medieval Realms e.g. using the combined search but used one of the three main single search methods, rather than the more powerful (but more difficult to understand) combined search. Few pairs were adventurous or prepared to try new features, perhaps as they were first time users.

9.21 Findings from the third layout task

The third task required the layout of one of the packages that they had used to be described or drawn. Both Fitter (1979) and Romiszowski (1990) have argued that the user needs to have an adequate knowledge of the system in order to make best use of the software (cf. Chapter 1). Task 3 aimed to test the student's awareness of the package's structure and the navigational options available to them, of one of the packages they had just used. The pupils were able to go back into the package. Younger groups had little idea of any potential structure layout, and they were not interested in understanding what was required. The middle groups had problems knowing what this meant, were then shown diagrams of a linear and a hierarchical structure, and attempted the task. Opinions on the specific layout of their chosen package varied, with some selecting a mixed or hybrid form using linear and hierarchical designs, which was perceptive for this age.

Generally lower ability pupils selected linear structures, and higher ability pupils preferred hierarchical ones. The middle group pairs discussed the structure and described what they thought it looked like, but none of this group wanted to draw their version of the layout. In retrospect this was a very ambitious task for this age group and in fact for anyone new to multimedia. The secondary group were given a blank layout sheet and asked to draw the layout/structure of one of the packages they had used. Most of the pupils followed the guidelines given on discussing the task of linear and hierarchical options and how topics could be placed in a multimedia environment. One pair showed good comprehension when they linked a circular series of boxes up to each other so they all joined and had internal joining boxes as well, constructing an advanced multimedia design. This concept of linking up to all areas was a significant one. It did not follow either of the linear or hierarchical routes described but came out of the discussion of possible alternatives to basic designs and how this relates to the multimedia package they had been using. The proposed structure was similar to the hypercube/ hypertorus structure of Parunak (Chapter 3).

9.22 Discussion of First study tasks

The degree of explanation of the tasks requested by the pupils varied with the type and nature of the task, and whether they were specific or self-selecting in nature. About 25% of the pairs did not like the open selection type tasks, but the others were happier with this. In this respect turn taking or sharing was important, as well as the amount of interest shown in the other partner's work.

There were few comments on the tasks such as why? how? The majority of the questions were basic, often clarifying points. The layout task proved difficult for the younger children who did not understand it conceptually, as they saw the package as a fairly linear sequence of information. The fact that they did not understand what they needed to do for the task, despite being willing to do it, was critical, as this showed a lack of understanding of the package's structure and the navigational options available to them. They had little idea of how to start the layout question and giving help would have negated the assessment of how much they had understood of the package's construction. Other questions were: off task items, what other pairs had done, and what software they used. Few requests for help/ help function were made as they resolved it or left the package.

9.23 User comments - Observations and Post observation interview

Sample comments from the pupils on four main topics have been included in Appendix 6 under the headings: navigation, software, tasks and requests for help. Navigation and software comments were the most common of these four categories, with each group having more than one of these, with the first choice accounting for 40-50% of comments, and the second category, 30%-40%, then task based questions and requests for help. Each group produced similar comments, apart from the very young group, whose comments related to their lack of comprehension. The post observation interviews (Appendix 2) concentrated on the most significant aspects and these have been synthesised. There was a great deal of valuable information from these interviews and the post observation interview was also included in the second study research methods. Single sex groups talked less, were less polite and were less deferential than mixed sex pairs, had more non-verbal communication, started work straight away, and spent less time asking each other what to do. The pupils' attitude was positive, as they were interested and well motivated.

The pupil's views and preferences for certain software seemed to be based on their ease of use. Some of the interfaces had set age ranges and appealed to particular group of users. For instance the Peanuts program and The Way Things Work, had definite age cut off points, where the children thought the interface was too young compared to the content. Some packages had a more general appeal, such as Eyewitness, which was liked by most groups, but packages such as Medieval Realms were considered too difficult to use. Other packages e.g. Grolier's Encyclopaedia had a mixed reception, which was based on the areas the children had looked at and how enthusiastic they were about it as a pair. Responses and methods of use varied, although there was similarity across the type of preferences they chose. Younger children would select pictures or video and were disappointed in sections without any; fewer of the younger and middle groups spent any time reading text. The older group read a lot of text and found the Eyewitness text poor and too brief, especially if they had previously used the larger text resource of Medieval Realms.

9.24 Conclusions

The results from the first study have provided evidence that individuals do have distinct navigational patterns and working strategies. There is some evidence to suggest that specific groups such as children and adults and novices and experts have similar preferences for patterns across the groups. However it may be that the variance within these groups is relatively small and that it depends on the skills and abilities of the user rather than the group to which they belong. It is likely that there is a continuum of experience of using multimedia, made up of the user's skills and experience but also their preferences in navigation and working. It would then be possible to place each user on this continuum and then relate sections of this longitudinal graph to novice and expert. It would then be seen that the novice is progressing along the same continuum, but in a different place to the expert. Similarly children and adults may be placed along this continuum and similarly have different positions along it according to their skills and abilities. Further research in the second study will look more closely at each individual user and assess how they individually prefer to navigate and work. The second study will also propose specific methods of analysing these navigational routes to allow them to be compared and to investigate the efficiency and benefits of particular routes. The first study has demonstrated that there is variance in how users employ navigational patterns, but that this is both recognisible and can be analysed.

10

Study 1: Navigational patterns

10.1 Introduction

Chapter 10 concentrates on the navigational patterns that were recognised from the first study and the research detailed in the literature review and further develops these into a usable classification.

10.2 Development of my navigational patterns series

The empirical work from the first study on investigating emerging patterns has been productive with the result being a new navigational patterns series. The navigational pattern classification was developed from the initial work on Study 1 – investigating the content of the observations, how users moved through the software and with the analysis of the observation tapes, together with the information gained from the literature review. The patterns recognised from the literature review did not seem to be very comprehensive and the work on Study 1 revealed a potentially greater range of patterns. The only element largely missing from the Study 1 observations was the complex patterns. These were added into the classification but it was necessary to expand the potential range of users (Study 1 had no expert users) in order to verify the existence of these complex or more detailed patterns. This chapter explains the nine navigation patterns that I have found and classified. The series is comprehensive and covers a wider range than the previously published sequences (cf. Horney 1993, Parunak 1989). These nine patterns are: linear, linear-extra, circular, star, star-extra, hierarchical, hierarchical-extra, complex-chaotic and complex planned. After detailed explanation of my classification, this is compared to other researcher's classifications, discussed in the literature review, and summarised in Table 10.5. This will necessitate some movement backward and forward through this chapter to relate the previous research discussion to my final classifications. After the classification was devised, the first study navigation patterns were reassessed to ensure their fit into the new classification.

10.3 Description of the Navigational Patterns

The chapter lists each pattern, and then expands this basic list into more exact and formalised specifications of all potential pattern types. An outline diagram of a graphical representation of the pattern has been drawn, although these diagrams may not be the only form allowable within each pattern type. The diagrams at this stage serve to give an indication of the type of patterns that may be expected under each pattern type. The first study indicated that basic pattern types could be recognised, although it was difficult to individually assess all the observed routes into the more detailed classifications. Further, more extensive testing is required to support these detailed subdivisions and this is one of the recommendations for future research work. My pattern list has been created by comparing individual or group's use of multimedia, within some controllable boundaries, and then checking to see if other users have employed similar patterns in multimedia. This would allow patterns to be amalgamated if necessary and the main series of resultant pattern descriptions made more distinct. However all the user's patterns observed from the first study could be put into these categories. The latter two categories of complex-chaotic and complex-planned provide final classifications for all of the complex or unusual patterns, as well as the very complicated ones, so this potentially means these two pattern types will form unusually large groups. Each navigation pattern description includes information on whether it is one-way or two-way, and how each pattern is different.

1. **Linear** - path on one level, using tools e.g. index, time line, or word search, one direction.
2. **Linear extra** - paths lead away from basic linear pattern, returning to the linear path, usually at the same place or the next node to their original leaving point.
3. **Circular** - initially recognised as linear, but circular if completed, one/two-way dependent on software design, may be represented by an ellipse/multifaceted shape e.g. an octagon.
4. **Star** - movement initially linear but implies a change in level, going into second level areas from the first level and returning, one way or two way. Complete star pattern can represent continuous topic selection through multimedia going into each item in turn to the next level and returning to starting level, especially with circular or thematic structures.
5. **Star extra** - a development or extension of the star pattern, movement into the second or third level of the package, i.e. into an additional level, beyond the usual star pattern, one or two way, and the extra depth may only be used for part of the route.
6. **Hierarchical** - movement down the hierarchy, with a possible return along the same path, to go down one or more branches of a tree structure. Progressing one way down the structure and across to the next branch of the tree, can be two-way, but unusually returning to the original starting point, but may retrace path.
7. **Hierarchical -Extra** - movement along multiple hierarchies usually with different subject/themes, usually in the same way, returning to the same tree structure or continuing onto a linked or associated tree. The hierarchical and extra patterns are differentiated by changes in depth and width as the extra extension may involve more than one tree structure, while the basic hierarchical pattern is confined to one tree structure.
8. **Complex - Chaotic** - movement follows a series of different paths, usually in rapid succession, random and erratic navigation, frequent changes of route and searching method, may be a mixture of the above types.
9. **Complex -Planned** - sequence of moves following established path, sometimes including definite patterns, using a mixture of different types, but following an ordered route. Types can be mixed within routes - with some recognition of each type but too confused/short for full classification. The complex patterns are the most difficult to recognise/analyse, as these may be hybrid forms of other patterns or result from rapid use of pattern types.

10.4 Navigational patterns in the first study

The navigational patterns listed were recognised in the first study, with the exception of the complex patterns (recognised from previous researchers but need to be empirically tested), which younger students did not use. These patterns are demonstrated below and graphically in Fig 10.1.

1. **Linear**

In the first study the linear pattern was recognised by the user going through the basic method of using the package, e.g. by following the index. Example: the user employing the index in Grolier's Encyclopaedia or looking at each item in the main menu in The Way Things Work.

2. **Linear-extra**

This pattern occurred when the user extended the basic linear pattern, i.e. using the index. The user may employ another linear method e.g. time line and progress along a Timeline, or by reverting back to the original linear progression. Example: in the Peanuts package, the user starts with the Math package and then the geography one, again in a linear manner.

3. **Circular**

The user looks at each section or area in turn and returns to the starting point and is often used as part of browsing behaviour, where user needs to find the package delimiters. Example: in The Way Things Work the user looks at each item in turn, progressing through before returning to the start point.

4. **Star pattern**

The user looks at the top level of the package and then moves down to the next level. For example -The Way Things Work, the user looks at the main menu and a subsidiary one but visits one choice of this (i.e. one level down) before returning to the main menu and continuing. The star pattern is difficult to differentiate from the circular, unless the user drops down to a different level. There is a difference in classification if the user goes down to another level occasionally, i.e. uses the circular pattern most of the time but occasionally drops down a level. The star pattern is popular with novices and may be the preferential choice of adults who like to check through all sections of a package, often when browsing or getting an initial overview. This pattern with adults may replace the circular pattern frequently used by children. Adults prefer to look at specific subjects in more depth (i.e. +one level) than children.

5. **Star-extra**

The star extra pattern involves the user going further down into the package before moving on to the next selection. For instance in Eyewitness History, the user looks at each historical period but goes into the next menu before doing the same with the next period. The user may then follow an associated or linked item to extend the pattern beyond the basic star.

6. **Hierarchical**

The hierarchical pattern is often recognised when the user researches in a particular subject and continues into the subject area. The user may then move down the subject category as if going down the branches of a tree structure, and getting into greater depth. It is also possible for the user to link with associated subjects and follows down links on this. Example: In Way Things Work, the user selects a subject such as electricity, goes into this subject and then moves onto another associated subject within the same category.

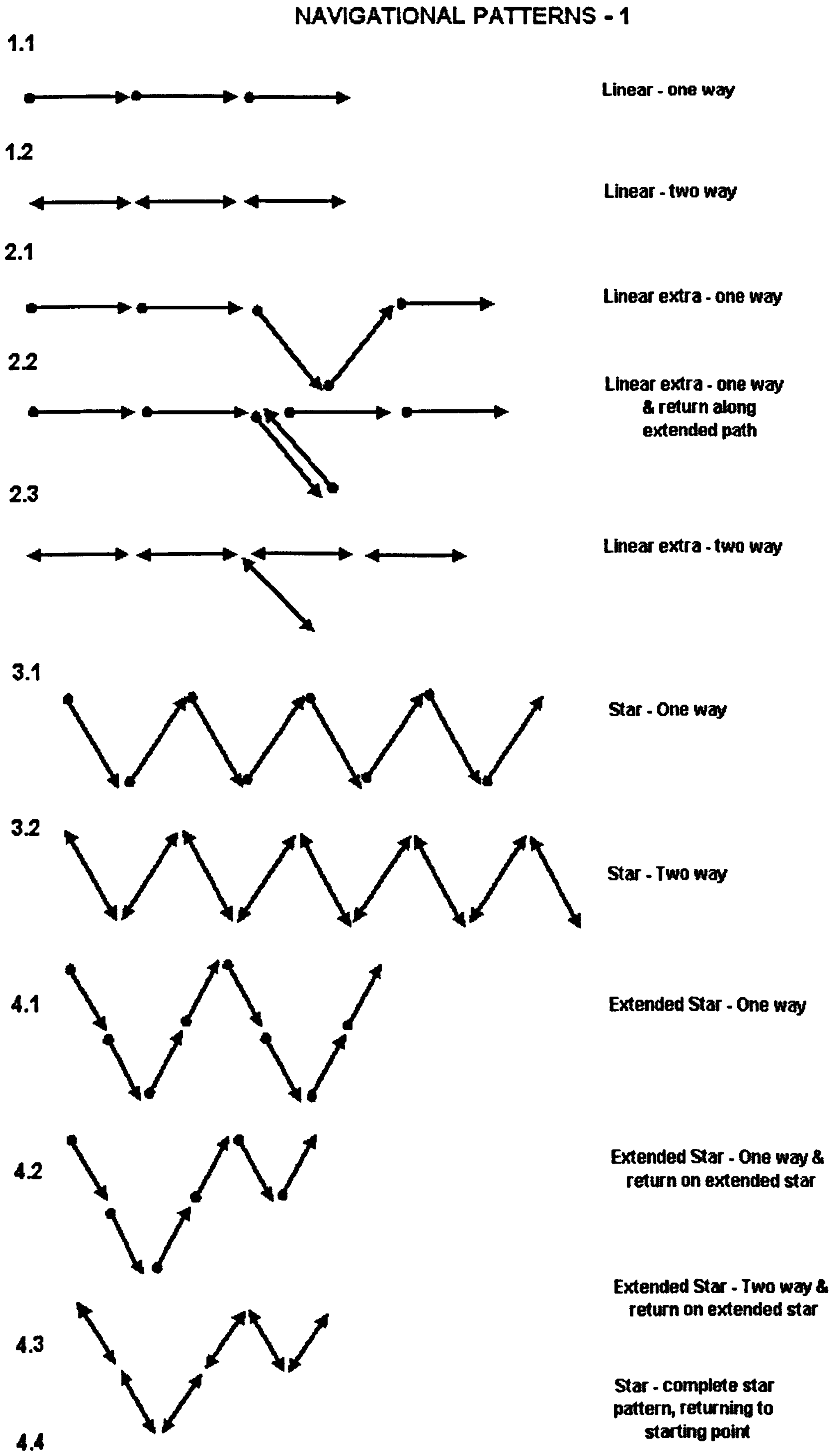
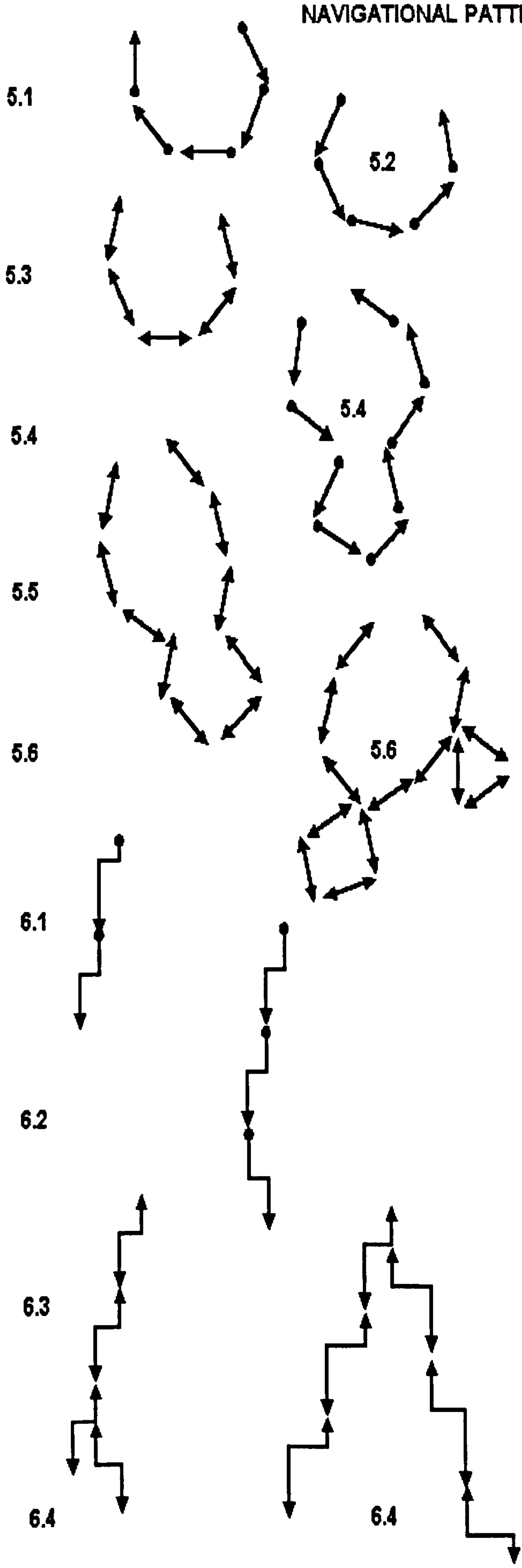


Fig 10.1 Graphical representation of the navigational patterns – 3 pages

NAVIGATIONAL PATTERNS - 2



5.1
Circular - one way clockwise

5.2
Circular - one way anti-clockwise

5.3
Circular - two way

5.4
Circular extra - one way

5.5
Circular extra - two way

5.6
Circular extra - two way with additonal circles

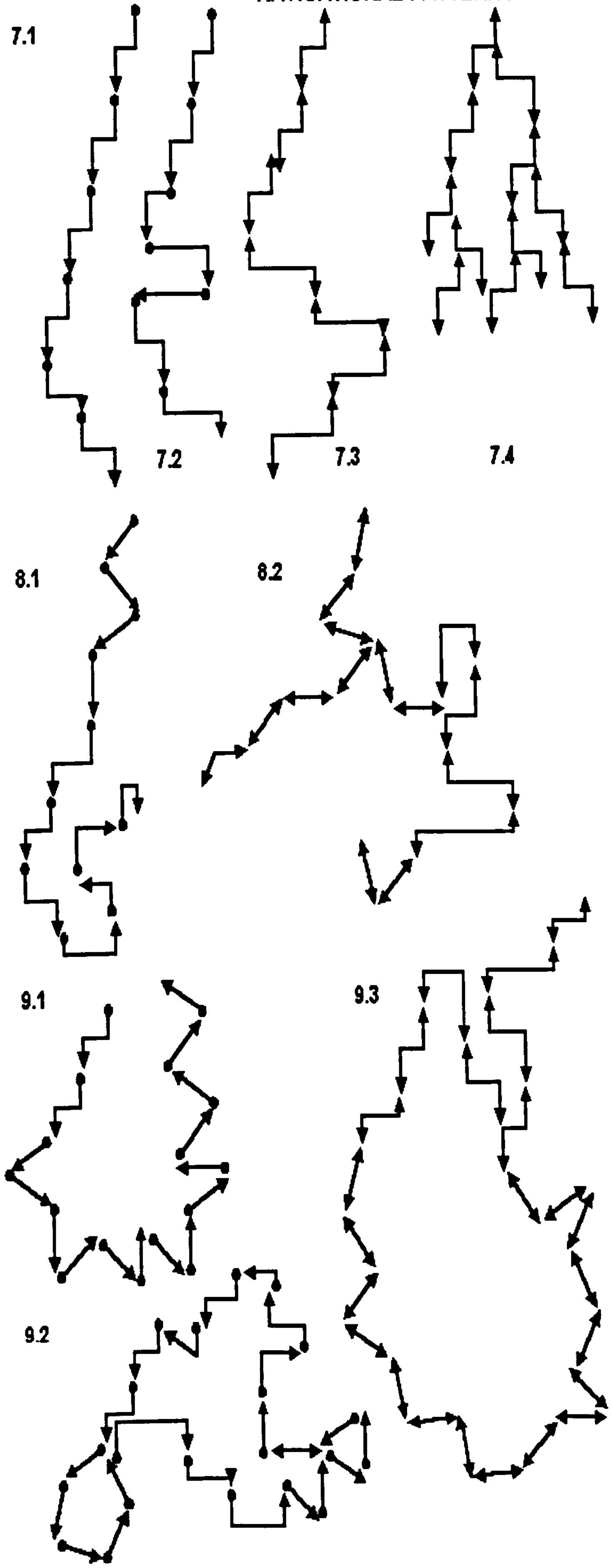
6.1
Hierarchical - basic one way

6.2
Heirarchical - simple one way

6.3
Hierachical simple - Two way

6.4
Hierarchical simple - Two way & return

NAVIGATIONAL PATTERNS - 3



7.1

Hierarchical extra - One way - simple vertical movement

7.2

Hierarchical extra - Two way - complex vertical movement

7.3

Hierarchical extra - Two way -vertical & horizontal movement

7.4

Hierarchical extra - Two way - complex vertical & horizontal movement

8.1

Complex chaotic - one way

8.2

Complex chaotic - two way

9.1

Complex planned - one way

9.2

Complex planned - one way or two way, loops

9.3

Complex planned - two way

7. **Hierarchical-extra**

The hierarchical-extra pattern is a variant of the main hierarchical type, with additional searches down adjoining or associated hierarchies. The extra component usually involves more searches and links to associated subjects or involved links with adjoining trees.

This searching is noticeable in older groups who are more prepared/ able to do long searches.

8. **Complex-Chaotic**

The complex chaotic pattern occurs when the user employs several different routes or patterns but for short periods of time and in an erratic way. The complex users are often more experienced users and although aspects of this pattern occurred during the first study it was difficult to see very much of this pattern occurring. Most of the users of this pattern were relatively slow and these slower navigational routes usually allowed a succession of different individual patterns to be recognised from the ones listed above.

9. **Complex-Planned**

Similarly to the comments on the complex pattern above, although it was considered possible for this pattern to be used in multimedia, the first study did not produce any convincing users of this type. Again as most of them were relatively inexperienced it was reasonably straightforward to assess each of their navigational patterns in terms of the range or mixture of patterns above. The pattern is included in the list for completeness and for use with the second study users, although there are not any examples of its exact use in the first study results.

10.5 Queries arising from the patterns

There are some queries arising from these patterns. The first of these is whether there is a difference in the user's starting point and whether or not all users have to start at the same point when in the same package. From the purely pattern point of view the starting point is immaterial if the pattern is the same, it does not have to be exactly over the same points even in the same package. Secondly and more crucial is the issue of completeness, again mentioned above. The areas where this is an issue, are with patterns such as the circular one, which forms a linear pattern until the full circular pattern is complete. It is often difficult to recognise the circular pattern until the user returns to the starting point to complete the pattern. Otherwise the route is classified as linear. In the case of a hierarchy, it only becomes hierarchical when the branching or tree feature is used; otherwise it is a linear route, even though it is vertical rather than horizontal in use. The other pattern with some difficulties in interpretation if incomplete is the star pattern, as this could be initially determined as linear (or possibly hierarchical). The star pattern definition by some researchers is not always specific. However my star pattern necessitates a change in level, which then differentiates the star from the linear pattern and is easier to recognise in practice.

10.6 Further navigational pattern subdivision

Table 10.1 (overleaf) lists the possible patterns. These smaller sub divisions of patterns (the right column) have been amalgamated into the major pattern types (left column) for the discussion below. These patterns were partially constructed from the routes the users took in the first study.

Table 10.1 - Subdivisions in the Navigation patterns classification

Navigation Patterns	Subdivisions
1 Linear	1.1) One way - uni-directional (no return) 1.2) Two way - bi-directional (return possible)
2 Linear Extra	2.1) One way (along path and extended path - no return) 2.2) One way (along path but may return from extended path back to original) 2.3) Two way (path and extended path)
3 Circular	3.1) One way - clockwise - single circle 3.2) One way - anti clockwise 3.3) One way - + multiple circle/loop still one way - not complete - no repeats 3.4) One way - + multiple circle/loop, complete circle, returns to starting point, no repeat 3.5) Two way - but not repeating loops - no repetition of path 3.6) Two way - with repeats on loops - multiple circles
4 Star	4.1) One way 4.2) Two way
5 Star Extra	5.1) Star extra/ Extended - One way 5.2) Star extra – Extended One way + return on extended path only - back to formal star 5.3) Star extra - Two way - star and return on extended star 5.4) Star complete star pattern, with return to starting point
6 Hierarchical	6.1) Hierarchical one way - no returns vertical path - no branching 6.2) Hierarchical one way - branching off same tree - no returns 6.3) Hierarchical two way - vertical tree 6.4) Hierarchical two way - branching off basic tree
7 Hierarchical Extra	7.1) Hierarchical - one way /no returns - vertical branching - possible multiple trees - vertical - unidirectional route 7.2) Hierarchical - one way - loops to other trees - return to main tree 7.3) Hierarchical - two way - vertical branching - more than one tree 7.4) Hierarchical - two way - vertical & horizontal branching - can return – multiple trees
8 Complex - Chaotic	8.1) Complex - unidirectional- no fit to above patterns - or mixture of above 8.2) Complex - two way - erratic - could loop/ cross hierarchies /stars etc. no set patterns
9 Complex - Planned	9.1) Controlled one way route - several search strategies, unidirectional no returns/ loops 9.2) Unidirectional - short loops off main plan, return to set pattern 9.3) Two way - planned includes loops/returns/different patterns-formalised path

There are extensions for the more complex ones, but these were not used by the children, but were apparent from the small adult sample in the first study. This list of all the potential variations of each pattern type was developed to gauge the number of possible variations along each type of recognised route. These patterns were used for the second study. It should be noted that although it is possible to classify user's navigation into the broad types, it was more difficult to determine the exact subtype and hence only the main classifications were used in this thesis' empirical work. Further development of accurate navigational route recording would allow further subdivision of each user's actual navigational routes. The pattern subdivisions consist of directional information, with returns/loops on the path, or changes of level as in the star, hierarchical and complex patterns.

Table 10. 2 - Relationship of other researcher's and my own navigation patterns

Fenley	Parunak	Canter, Rivers & Storrs	Horney
Linear	Linear	Path (Pathiness) any route not crossing node twice	Linear Traversal
Linear Extra	-	Loop (Loopiness) ring, which Contains no other rings	Side Trip
Circular	Ring	Ring (Ringiness) Returns to start node, May include other rings	-
Star	-	-	Star
Star Extra	-	Spike (Spikeness) retraces path back	Extended Star
Hierarchical	Hierarchical	-	-
Hierarchical Extra	DAG	-	-
Complex -Chaotic	Arbitrary	-	Chaotic
Complex - Planned	Hypercube/ Hypertorus	-	-

10.7 Comparison of other researcher's navigation patterns

The navigational patterns classification has been compared to other researcher's series (Table 10.2) and the nearest comparable patterns listed. These patterns can be recognised in the work of five other research groups: Horney; Canter, Rivers and Storrs; Parunak; Trumbull, Gay and Mazur; and Beasley and Vila. Horney's classification has been detailed in the literature review and the graphic description of his patterns (Fig 2.3) is helpful, and needs to be reviewed here. Horney's classification of his linear traversal is again a basic linear pattern with one-way direction. Horney's Side Trip pattern allows movement away from the linear direction but necessitates a return to the same node before continuing on the linear path. His Side Trip pattern can be either one-way or two-way, although the two-way sections are always on the side trip extensions. This pattern conforms to the linear extra pattern, but is less specific. This is because in the full version of the pattern types that I have produced, there is a possibility of one-way direction only if the user returns to the path further on than where they exited on a side trip, thereby not covering any ground twice. In practice it is more likely that linear users would return to the node they initially left and so Horney's interpretation of the linear extra encompasses the most common usage of the linear extra path. Horney's patterns were only tried out on eight users and so the possible variations observed may have been limited.

Unfortunately Horney's more recent published work has not returned to investigating navigational patterns. It is necessary to fully test these navigational paths on larger numbers of users to determine the degree of variations within each main pattern type. Horney's star pattern implies moving away from a central node and returning to this node before continuing. This reflects the architecture of a specific type of software package, and this is not a common design of multimedia packages. In my classification the star pattern occurs when the user moves down a level in the package and returns up to the original level. It does not imply that the user must return to the same node. Horney's extended star is a valuable development as users move away from the original point and may do this in various directions and to different levels. Again Horney's extended star necessitates a return to the central node, which is unlikely in multimedia, but my extended star necessitates a change in level (possibly + one level in the extra pattern), before returning back, but not necessarily to the original point before continuing.

His final pattern, chaotic is an all-encompassing category, which includes any other pattern that a user could employ. This has the potential of being a huge category and needs further refinement. It is constructive that Horney has recognised that there is a category, which cannot be fully explained with a sequence of definite types. Horney does not recognise the need for a hierarchical pattern, although it may be possible to use his extended star pattern in this way, if the user returned to the same base point, but this is not very satisfactory. Horney's classification though is a good framework to start with and can be augmented and further tested empirically.

The pathiness index of Canter et al. is a typical linear path in my classification. The ringiness index is most like my circular navigational pattern. Although the loopiness indice resembles the circular route it is more like the linear extra. This linear extra allows additional trips away from the basic linear route, usually returning to the node or the route from which they originally diverged. The spikeness index is most like the Star extra pattern, however it implies that the only route that the user can take is to retrace their steps, which means that the software is forcing this route. The other major researcher who has created a series of pattern types is Parunak (1993, detailed in Chapter 3, Fig 3.1). His topologies (rather than his strategies which are not as appropriate here) consist of linear, ring, hierarchy, directed Acyclic graph, hypercube, hypertorus and an arbitrary category. The linear topology is a one way, sequential route following each node in turn and can be interpreted as a standard linear route. This fits closely to my linear pattern. However Parunak's series does not include any two-way linear patterns.

Parunak's ring topology has been represented as a completed ring and is again one-way. This is similar to the circular pattern but again has no option of being one or two-way. There is also a problem of whether or not the pattern has to be complete. If the pattern is incomplete is this still a ring under Parunak's classification, or does it then become classified as a linear pattern? This is a real problem with all the classifications as it is not obvious that the pattern will be circular unless the user returns to their original starting point. However the structure of specific multimedia packages may mean that it is possible to track the navigational route of each user and determine if the path is circular (for instance). Having a more defined series of patterns may alleviate this problem, as it should be possible to observe the user's path and determine whether or not they are navigating in a purely linear manner or whether they are investigating each section of the package in turn and therefore progressing in a circular pattern. Parunak's hierarchy topology is a simple one-way hierarchy with no returns along the route and relates closely to my hierarchy pattern. The directed Acyclic graph in my interpretation is the hierarchy extra as this allows the user to branch along other related trees, which is the function Parunak allows (although only one-way) in the Acyclic graph topology. The hypercube and hypertorus topologies are both very remarkable, as they would make excellent structures for certain types of multimedia resource, i.e. in resources where there is little or no necessary sequential order in the information blocks that need to be displayed. Unlike his other topologies these are both two-way and form very flexible navigation patterns for the user. These structures may allow for the complex planned movement through multimedia that I have envisaged. However they are rigid structures and therefore suggest that the user has to progress in a specific pattern, or alternatively in a prescribed order of nodes.

These may therefore not be as flexible as the initial image given by Parunak proposed. Because of the potential need to follow through the resource in a prescribed pattern these may not be very similar to the complex category, but this would depend on how they are used. Due to this uncertainty in how these patterns would be used, together with the present lack of any multimedia structures arranged in this format to test empirically, I have decided to have a complex category with both chaotic and planned subdivisions (termed complex-chaotic and complex-planned). Parunak has an arbitrary topology presumably designed to encompass any other pattern, which does not fit into the rest of the series. Again this is critical as it allows a more open and potentially large pattern category for any non-conformist pattern types. Finally when discussing Parunak, it is important to remember that he was purely theoretically and did not empirically test his topologies.

Relating these discussions to researchers with more restricted series of navigation patterns, such as Trumbull et al. and Beasley and Vila, there are some relationships between their limited classifications and my classifications. In Trumbull et al.'s work their Index strategy is comparable to my Star pattern with the Index display serving the root. Trumbull et al.'s Browser category relates to my linear pattern or Horney's Linear Traversal, and their guide tool is perhaps similar to Horney's Side Trips or my Linear extra. In Beasley and Vila's work their linear strategy relates to Horney's Linear Traversals or a generalised linear pattern while their non-linear pattern is most similar to Horney's Side Trips, and as in Horney's classification it is not really hierarchical at all.

10.8 Discussion

A significant element of the research in this thesis has been exploring the relationships between navigational patterns and the ways users prefer to work, which forms the main connecting thread into the next chapter. Beasley and Vila's research looked at possible relationships between navigational patterns and ability. They concluded that lower ability users used a more exploratory approach and higher ability users were more linear. However the differences between these two groups and the statistical significance is not great and may be explained by external factors. These factors included whether or not the users have been taught how to use the software in the same way, their usual learning or teaching methods, their exposure to computers and previous use of multimedia in particular, their age range and the task they have been given. With the additional restraints of time and the pressure of completing set tasks the users may not always choose their preferred method of using the software. Instead they may be totally controlled by other factors, such as their need to complete the task in the minimum amount of time. In Beasley and Vila's work they also investigated the relationship between navigational patterns and gender.

This is more difficult to determine and specify, due to all the factors mentioned above, only some of which can be controlled for in an experimental setting, and this question did not relate directly to the research questions in this thesis. Both these issues require further work, but the main issue for my research is if these navigational patterns can be learnt or improved and how they enhance working strategies, and from this contribute to multimedia improvements for users. The points raised above all support the potential need for an intelligent tutor to be developed. This is an underlying set of programs, which would create an expert system type application, which would be closely connected into the main multimedia package. This could record the student's use of the package and their preferred navigational paths and learning styles.

The intelligent tutor could give context relevant help, which would also be associated with their level and ability as well as the factors above. The program could then suggest the best, or a list of optimal, routes to find certain information even giving the amount of time needed for certain search types/ routes. The intelligent tutor has the potential of being expanded into a tutor companion role where the package is not only monitoring where the student is going, through the history function, but is also relating this to other successful searches by other users. The help on navigation should be linked to the student's own preferences or the specific task. The teacher could suggest optimal routes/alternative methods of reaching the goal by using the most economical or interesting routes. The best route approach may overcome problems if the user is lost or disorientated and needs to return to their route.

A problem of using multimedia in a classroom situation is that the time available is resource dependent and hence restricted. Encouragement of free browsing or learning may be very time consuming. This freedom may have to be tempered with a more controlled or ordered use of the software for practical as well as pedagogic reasons. One of the main disadvantages of the use of pairs was that it appeared to camouflage each individual's choice of navigational patterns, as the route chosen was in most cases a hybrid form of their two choices. In a few cases each pupil resumed their own personal preference as to where they went and would ignore where the other pair member had gone. They would either return to where they left or continue in their own way.

This showed that some pupil's preferences were critical and their preferences overrode that imposed by their partner. An additional point from the results of the empirical work is that several pupils stated that they needed to have a purpose to finding information, and if there was a specific reason this would help recall. Unless they personally had a use for it they did not seem to enjoy or benefit from the multimedia session. There were also difficulties with the audio recordings as some were of poor quality, as some pairs were quiet and others deliberately whispered or used sign language to avoid being recorded. This awareness of the recording and the avoidance attempts were particularly noticeable with older pairs. In the second study the observation sessions and voice comments were recorded unobtrusively via a scanner.

10.9 Conclusions

In this chapter the empirical work from the first study together with the literature review has been used to create a series of navigational patterns, recognised either partially or fully in the observational work on a large group of pupils. These navigational patterns will now be tested on adults in the second study. The elements of the literature review to be carried forward to the second study are findings from other researchers, on group size, task allocation and pairing. Crucial points from the first study include the type and nature of the tasks, the amount of time it takes to orient a user, varying ability levels and the different requirements of different software.

There is the future potential in being able to subdivide the complex classifications when greater numbers of individual navigation patterns are recorded. Navigational patterns research can benefit novice pupils in particular as they can be given help on the most suitable route, or be informed about routes that experts found best. This help could be available at different stages in the multimedia session, i.e. for novices, early in the session and for intermediate users, after they had tried the tasks. For experts this information could be provided with suggestions on faster or more productive searches, so that they too can improve in future task performance.

Referring back to the key questions, the first study results have revealed that individuals have distinct preferences for certain navigational patterns. Examples of the use of specific patterns in Study 1 are in 10.4. The analysis of the observation sessions shows distinct patterns especially linear and hierarchical patterns. Some users have preferences for specific patterns e.g. star and circular, the latter where they show the need to complete a search by visiting every item in turn. Specific pattern preference is also shown with pairs which do not share navigation, but who revert to their own preferred methods at each turn, which was very noticeable with users preferring very sequential or linear methods, or with those who needed to visit each node in sequence such as in a linear, circular or even star pattern.

The second subsidiary question on whether navigational preferences are related to the pupil's approach to the software needs to be reassessed after the navigational patterns have been defined and this will be done in the second study. Finally on the research questions, the third subsidiary question on whether or not there are differences in the preferences of groups e.g. children vs. adults and novices/ experts, has been only partially addressed here from the perspective of the children and this needs comparing to the adult patterns found in the second study. The fact that the children had distinct preferences and that there was similarity over their choice of pattern within the group is a positive result. However it is not yet known if adults have the same pattern preferences and how these differ from the children's.

Finally differences in navigational patterns between groups are analysed after the second study. Regarding the different perspectives investigated in this thesis the navigational patterns work concentrates on the designer and user perspectives. Further research and analysis of the pedagogic and HCI perspectives will be done as a result of the second study research. The navigational patterns research has determined that the design of the package not only affects, but often also constrains the user's navigation. The fact that each user has preferred navigation patterns should be recognised and used by the designer to customise rather than constrain their software for each individual user. The user issues are: how well these specific patterns are used by the individual, in what combination and with what skills and abilities.

11

Study 1: Working strategies

11.1 Introduction to the working strategies research

The previous chapter investigated navigational patterns. This chapter considers working strategies, analysing the first study results and using these in conjunction with the research literature as a vehicle for classifying these working strategies. There are different approaches to the order of discussion as these strategies were developed jointly from the literature and the empirical results, and the sequence in which the research is reported does not mean that later work is less significant. Firstly the series of four working strategies is described. Secondly each of the main researchers with comparable work in this area is assessed in relation to this new series. A short resume of their research is included here, (detailed in the literature review), and this has been discussed with regard to navigational patterns. A significant issue for this chapter is how different researchers use various terms such as browsing and their exact meaning in their use of working methods or strategies. The working strategies analysis divides the research into specific techniques and strategies, e.g. Conklin's work (1987) on different ways of browsing in a database; Trumbull, Gay, Mazur (1992) on using tools such as a browser, the use of search strategies by Canter, Rivers and Storrs (1985), and Frau, Midoro and Pedemonte's (1992) research on using an educational hypermedia system.

11.2 Working strategy definition and links to navigation patterns

In the previous chapter navigational patterns have been described in some detail. The term 'navigational pattern' as defined in this thesis (cf.1.10) is the physical or comparable geographical method a user employs to move through a multimedia resource. The working strategy definition relates to the individual user's preferred methods of working while using the multimedia resource. The working strategy mirrors the mental processes the user has gone through, and the methods they use to relate the material that they have found together, with the new material and with their existing knowledge base. There are distinct connections between the navigational patterns and the working strategies which users employ. After the initial empirical work a series of working strategies were developed which related to the way people navigated and used navigational patterns. The navigational patterns are evidenced from the specific route the user has taken through the resource and hence can be viewed from the navigational charts developed for the empirical study. Information on the working strategies was found in the initial pretest questionnaires, from the user's comments during the session and from the post-test interviews afterwards. However the exact navigational patterns used were not always synonymous or uniform with the preferences users had for working strategies. Users have definite preferences for distinct working strategies. These preferences followed a similar overall pattern, in that there were more popular and ubiquitous patterns, with some more restrictive or only used by distinct user groups.

The common patterns were researching ones, and for some of the types there were common associations. It was possible to relate common navigational patterns with the frequent use of specific working strategies. Due to the nature of the working strategies these are often difficult to determine exactly, but looking at the decision points in their route, i.e. the points they reach at the end of a text section or when they decided to follow a hot link, these can be used to assess their thinking and determine why they decided to continue their search in a specific way. These decisions were explored further in the questionnaires/interviews, which asked questions of how users would prefer to use the resource, as well as on the most beneficial multimedia designs.

In the first study children found the questions on their working strategies and the mental processes they used in deciding where to navigate within the software difficult and the children tended to use very basic methods. Hence the links between specific navigation patterns and distinct working strategies were not very clear in the first study. This may be explained by the children using mental methods to work through the resources but not articulating them sufficiently well for these to be categorised. However there was enough of a range of different comments and views from the children to produce a specific list. The analysis of each individual's working strategies were also complicated by their being in pairs, although for this group of users it is doubtful whether they would have given any information on their preferred method of working if they had been completing the multimedia session on their own. In the second study adults should exhibit more easily recognisable strategies for working. However it is expected that adults will also use these four main strategies. The adult users are therefore more likely and able to explain their methods of working, and preferred strategies, than children. This relates back to Landow's analogy (1990), referred to in the introduction. Landow considered that navigating in multimedia was similar to the art of controlling the course of a plane or a ship, as multimedia is experienced as a spatial world. Navigational patterns determined the ship's or plane's course through the geographical space and the working strategies are the choices made in the route, based on preferences by the navigator.

11.3 Working strategy classifications

From an investigation of the literature and observations from my own empirical first study a series of working strategies has been developed. These are compared in Table 11.1, (in 11.10) where my strategies are broadly related to other researchers. A comprehensive list of all the potential strategies is needed as well as better definition of the terms employed. The terms used by other researchers were open to a number of interpretations e.g. the term browsing has been used to refer to several different activities. The choice of terms used in this thesis has been very precise especially in the allocation of terms for describing specific observations. These four strategies are detailed below:

1. **Orientation strategy**

   The orientation strategy describes a navigational technique of looking through the software rapidly with the user familiarising themselves or becoming aware of the package's limitations and parameters. Users of this method often move rapidly through the package having a 'quick look' at the most relevant areas and skimming over the contents. This was often an awareness raising technique, which incorporates very little in depth research, virtually no reading and no investigation of any particular subject. This strategy usually means that a large proportion of the resource was investigated, albeit in a fairly superficial way. This strategy can be termed browsing, and this term is used when the user cursorily visits different screens, with no clear intention or direction and for insufficient time to be able to fully read the text.

2. Researching Strategy

The researching strategy is a more thorough and comprehensive approach to using multimedia. The working strategy relates to the way they perform this search and the mental activity they follow. It is an ordered and structured strategy and the user is usually quite deliberate in using it and continues to use this strategy for long periods of time. It can involve a thorough investigation of the whole resource or can be more restricted to a selected section(s). The main technique was one of going through the resource meticulously and having an awareness of how the package was structured, and following paths within that structure. The researching strategy is usually performed with a distinct route in mind and so can be related very closely to particular navigational patterns. The user in this case is travelling through the resource in a specific navigational pattern (such as a linear or circular one), so there is a clear relationship with the navigational pattern they are using. However it was the strategy that was critical here and this strategy could involve using more than one navigational pattern, such as linear and circular or linear and star, usually in sequence, for it to be fully implemented. The strategy may not involve searching the entire resource.

3. Studying Strategy

The studying strategy again involves a distinct 'modus operandi', but this time relates to the user following different, but distinct routes through the resource, such as the hierarchical pattern. The user works consistently through the resource looking and reading each level of the resource before continuing on. The user often exhausts all the available material on a specific subject before moving on to a different subject or following another link. This may involve retracing some steps to follow up a link covered earlier on in the session, and hence is more often related to two-way navigational patterns. The studying working strategy can involve looking at different levels of the package successively, and/or investigation of the subject to some depth, and involves some repetition. The user investigates the way the resource connects up information, and looks at a whole series of types of information, from a thematic viewpoint. Although it is often associated with hierarchical patterns of navigation, other patterns such as complex navigational patterns may be employed.

4. Composite Strategy

The composite strategy was the most difficult to assess, as although the user has ideas on the routes(s) or method of progression, these were not immediately obvious to an observer. There are two distinct modes within the composite strategy, 1) a random and 2) a planned mode. The user may look at certain topics or types of information, or do a mixture of these two. This strategy usually links to a mixture of navigational patterns.

1) The composite random strategy uses small sections of distinct strategies but for short periods of time and the user can jump between different strategies. In the random mode there appears to be little structured thought processes done in advance of the type of work needed for a particular subject area. The majority of decisions seem to be made at the time and the strategy is readily adapted to the information and links that are uncovered and the relevance and importance of these information points affect how the user progresses.
2) The composite ordered strategy is more pre-planned and the user has developed a mental plan of how best to work through the resource. This planning can be seen in a more measured (but often fast) use of the necessary strategies at each point or node in the information resource. The composite ordered strategy was complicated but the user's processing through the resource could be recognised. The related navigational patterns were likely to be a mixture of different types.

The composite strategy was one of the most significant as it was varied and did involve the user thinking and planning while using the resource. The use of the composite pattern can be ascertained from the navigational decisions made during the user's sessions, but interviews are needed to allow the user to give an explanation of why these choices were made. Frequently the user sets themselves distinct goals from within the available resource, and they are usually experienced and reasonably sophisticated users of multimedia. The user often works competently and well with this method, is aware of all the navigational methods available, and uses the most efficient one in each case. The second empirical study should be relevant in this context and in defining exactly which strategies adult users employ. The tasks (specially the second one) were designed to encourage users to view topics using their preferred methods but for a restricted time.

11.4 Navigational patterns and working strategies relationships

The navigation pattern's research can be used to help users learn more, or more successfully, from the multimedia resource. It is therefore very significant that the navigational patterns are related to the working strategies so that both the physical and mental aspects of the process of navigating in multimedia are linked. The differences between the patterns and the working strategies need to be explained. The navigational patterns refer to the route that each user takes through the multimedia resource, i.e. which sections of the software package are visited during a specific search. The navigational pattern can be described as the geographical or physical route that the user employs to move through the multimedia resource. As multimedia is often three-dimensional the navigational patterns or combinations of these can be quite complex. The working strategy refers to the methods the user employs to move mentally through the resource. This mental working strategy usually requires some thought before commencing the search. This mental preparation, analysed from the first study routes, the children's comments and the interviews, varied between users and it is expected that this will vary considerably in the second study both between individual users and between types of user (with implications for both expert/novice and child/adult users). These two aspects of navigational patterns and working strategies are related and some users in the first study used similar navigation patterns and working strategies, although the majority of the first study users were novices. Several researchers such as Parunak, Horney, Canter (with Rivers and Storrs) and Trumbull (with Gay and Mazur) have also noted this distinction. Each researcher's work on working strategies will be investigated with special attention to the research related to new working strategies described above.

11.5 Techniques and Strategies employed

The next stage in the research process has been to investigate those researchers who have also recognised differences in the physical and mental patterns of users. Different groups of researchers have worked on this area, but as there is variation in the terms and their usage, these differences need to be explained before comparisons can be made between the research projects. Lieberman and Linn (1991) believed that variety and flexibility were major advantages of computer based instructional technology. They contended that the unique and diverse environments that can be created in these systems, can supply and manage vast quantities of information, interact with the learner, adapt to individual needs, provide private and social learning experiences, stimulate a range of cognitive styles and blend explicit tutoring with experiential learning. Lieberman and Linn stated that these were all possibilities but they did not cite any software where all these attributes can be met, although they indicated where this might occur. One of the main aspects of self directed learning was in developing the abilities and skills of the learner, and the learner could be given the skills and allowed to develop their abilities in specifically designed multimedia. Although at present few multimedia packages at present teach or even encourage these attributes. Multimedia developers need to include methods of learning and skill development along with the skills to use the package successfully. Misanchuk and Schwier (1992) whose work was detailed in the literature review made the following statement:

> Perhaps the most potent use for audit trail data is counselling and advising the user, on the fly, about how choices are made and the paths taken may bear on future choices or outcomes...The data bank could form the basis for a comparison of the learner's path choices with data collected from prior learners, to provide suggestions about what other paths might interest the learner, what paths are most likely to be rewarding in terms of learning accomplishment, or what difficulties the learner might be expected to face if particular paths were chosen (p.363).

Misanchuk and Schwier considered that audit trails could be stored and interpreted on the computer, and they could be used to construct data banks from which inferences were made. The benefits of audit trails can also be applied to the classification of navigational patterns. Classifying the user's navigational patterns, and relating them to the most suitable working strategies should produce methods of using multimedia that create the best educational environment. These working strategies will now be reviewed and four examples are used here:

Working strategies examples	Research authors	Location	Lit review
1) Using different methods of searching	Conklin 1987	11.6	3.4
2) Using tools such as a browser	Trumbull, Gay, Mazur 1992	11.7	3.8
3) Using search strategies	Canter, Rivers & Storrs 1985	11.8	4.2
4) Using an educational hypermedia system	Frau, Midoro and Pedemonte 1992	11.9	4.3

11.6 Using different methods of searching

Conklin (1987) connected hypertext to semantic networks by analogy, stating that:

> A semantic network is a knowledge representation scheme consisting of a directed graph in which concepts are represented as nodes, and the relationship between concepts are represented as links between them (p.17).

Conklin stated that the browsing of a database could be done in three distinctive ways:

1. By following links and opening windows successively to examine their contents;
2. By searching the network or part of it for a string;
3. By navigating the hyper-document using a browser that displays the network graphically.

Conklin identified a number of problems with hypertext; that references cannot be traced backwards, the reader must keep track of which documents he has looked at and which he has finished with, any annotations must be put into the margins or a separate document and that using electronic documents, although faster than print based ones, was still a tedious process. The advantages of Hypertext listed by Conklin were: ease of tracing references, the ease of creating new references, information structuring, using global views and customised documents, the modularity of information, the consistency of information, task stacking, and collaboration. Conklin stated that there were two major technological solutions for coping with disorientation: graphical browsers and query/ search mechanisms. He qualified this by stating that with poorly designed hypertext (or multimedia) it would be almost impossible to prevent disorientation purely by having a browser.

This is relevant to the designer perspective, as Conklin listed poor design indicators such as: large numbers of nodes or links, slow response times, and little visual differentiation between nodes. He brought the user issues into consideration when he considered that these problems would be exacerbated for users if they themselves were non-visually aware. He believed that these problems could be resolved by standard database search and query techniques when locating particular nodes. Finally Conklin dealt with what he called 'cognitive overhead', by which he meant the ability or need to create, name and follow links within the hypertext. He argued that this cognitive overhead happens each time the user has to make choices at a particular link, and whether or not the user has enough information (informational myopia as he termed it) to make a good selection. This problem was dealt with by making the links appear rapidly, giving a short explanation of the link and having a graphical browser showing the sub network of the link.

Conklin stated that, as the hyper-document grew more complex, the following happened:

> It becomes distressingly easy for a user to become lost or disorientated (p.17).

The problem of disorientation was covered by hypermedia researchers, but was less of a phenomenon with hypermedia than with true multimedia, and was less of a concern with multimedia. This reflected the observer's concern that the user had not followed the prescribed path rather than user's problem. In the process of information seeking, the two major problems relating to web navigation were: the user's cognitive overhead /overload and their disorientation. Cognitive overhead is the additional effort and concentration necessary to maintain several tasks or trails at one time; disorientation is the tendency to lose one's sense of location and direction in a non-linear document. When users encountered these problems, they became lost within the web space. In terms of web navigation and the research on this topic, solving these problems is a significant issue. Conklin's recognition of the user's 'cognitive overload' supports the belief that the user employs cognitive strategies for making mental decisions on where to move on through the resource. The cognitive overload phenomenon relates closely to the concept behind the working strategies and it is relevant that Conklin also recognised the need for recognition of both navigational patterns and some form of cognitive strategies.

11.7 Using tools such as a browser

Trumbull, Gay and Mazur (1992) investigated students reading hypertext on cultural entomology. Their work was analysed in the literature review (cf. 3.8) and was commented on by Horney. They grouped students under four headings according to which of the three main navigational tools they predominately used: Browser, Index, Guide, or Mixer. Trumbull et al. considered the user issues and determined that hypermedia users should develop systematic ways to use the system, and that hypermedia systems should be designed in order to help users develop effective search strategies themselves. Trumbull et al. found that different search modes affected the amount of information found, and they attributed this to the thematic arrangement of the Index, but they did not include information on the complexity of the information web and of inter-relationships between topics. One group of students, the mixer group chose a mix of strategies, which meant, from Trumbull et al.'s viewpoint, that these students 'were wandering and not monitoring their own work' (p.325). These students might have been trying out different strategies to see which were the most productive. In Trumbull et al.'s research the tools were used for navigation but they focused on the decisions each of their users made within the multimedia. This enabled them to classify each student's working preferences, and to classify them into distinct groups. These findings support this thesis' hypothesis that individual users do have their own preferences and that these are recognisable and classifiable.

11.8 Using search strategies

Canter, Rivers and Storrs (1985) discovered five search strategies to do with ways of learning. These have been detailed previously, (4.2) these were defined as: Scanning, Browsing, Searching

Exploring and Wandering. The series of working strategies recognised by Canter, Rivers and Storrs has a great deal of similarity with those recognised within the first study. However the description of each type of strategy is not exact and this makes recognition of each type in a different context more difficult. Although there are definite associations between the scanning, browsing and exploring strategies and my working strategies, it is more difficult to match the searching and wandering strategies. This may be because the searching strategy is not sufficiently specific to be recognisible in another context, but it is clearly fixed to the spike navigation pattern. The wandering strategy is more easily accommodated in my composite strategy. The key fact is that Canter et al. recognised the distinction between methods of navigation and methods of working and although they treated these as two separate entities they linked navigation patterns to the descriptions of various types of working strategies. This distinction between the strategies is not specific enough to be used elsewhere and these need clarifying. This will be determined here.

11.9 Using an educational hypermedia system

Frau, Midoro and Pedemonte's research (1992) used an educational hypermedia system on earthquakes called Terrimonti with 36, 17-year-old students (cf. 4.3). Their aims were to look at the strategies, tactics and solutions used and the problems they encountered using this system. They concentrated on user issues such as the modes of interaction, strategies used to investigate the software, problems experienced using the system, and the learning effectiveness of the students. They wanted to investigate student's interaction with the system, evaluate the system's effectiveness and to identify different types of strategies of browsing and compare them on the basis of the resultant learning. The user's initial choice of module was significant as the majority of the students selected the module at the top of the screen, supporting my theory (Fenley, 1997) that students would preferentially select options/icons from top to bottom and left to right. Beasley and Waugh's (1997) study identified the predominant patterns of navigation employed by users in a constrained hypermedia package. Users initially employed a systematic, top-down, left-to-right (depth-first) navigation strategy to ensure full coverage and then reviewed the material in a more sporadic and less systematic manner. Factors such as culture, language, other biases, the hypermedia organisation, and user's goals influenced user's rationale on with using hypermedia.

Returning to Frau et al.'s research, the students stayed in the module until they had exhausted it rather than try another, displaying a sort of cognitive inertia, with the first topic choice (made from its screen position or the users' interests), being significant due to the amount of time spent on it. The second choice was selected because of its relationship to the main themes. Frau et al. found that 20% (a large proportion they thought) of time was spent on how the system worked, understanding it and accessing functions and structures. This was done in two ways a) by using deductive methods - looking at the system, seeing if it was appropriate and using the learning materials and b) by inductive methods - using the material and looking for system information. They considered that elements such as diagnosis, reinforcement, feedback and motivation were necessary to make the software more functional. Their conclusions support my view that these stages must be built into multimedia software if a learning conducive environment is to be created. Their work is especially relevant to this thesis because of their emphasis on the user perspective; especially the way users employed multimedia packages, i.e. their navigational patterns. My observations indicated that novice and younger users tended to use systematic and linear methods with multimedia. Greater understanding and knowledge occur if the user follows a thematic, or hierarchical approach, hence my empirical results support those from Frau et al.'s work.

11.10 Comparison of this thesis and other's working strategies

The research in this area and all the different approaches now need relating together. Table 11.1 relates my search strategies to those of other researchers.

Table 11.1 Comparison of working strategies from different researchers

Fenley	Trumbull Gay & Mazur	Conklin	Frau, Midoro & Pedemonte	Canter, Rivers & Storrs
Orientation-Quick Look Delimiting	Browse	Following links, Opening windows to examine content	-	Scanning Covering large, Area- no depth
Researching-Ordered/ Structured	Index	Searching Network – or Part for string	Topics/Index	Browsing Following path until goal achieved
Studying – Hierarchical	Guide	Navigating using Network graphically (Using browser)	Maps	Searching – Finding Explicit goal
Composite – Random	Mixed	-	-	Wandering- purposeless, Unstructured globe trotting
Composite – Planned	-	-	Dictionary Anthology Author /article	Exploring /finding the extent of info given

The use of orientation strategies usually meant that the user was covering a large area, but without great attention to detail. Variations in this strategy may indicate the extent to which this method was effective in seeking particular goals. The analysis of these variations may allow development of more effective ways of scanning/ browsing, especially if this was the strategy of choice. There was an element of experience in the use of working strategies. This raises two questions, 1) does repeated use of multimedia refine the working methods and improve the effectiveness of a particular strategy, and 2) are experienced users more likely to develop complex/ composite methods of investigating multimedia resources? There was a specific motivation to searching, and the significant reasons users have for choosing specific strategies will be explored in the post-test interviews. Issues that need to be addressed are which techniques yielded the best results and whether users made unplanned forays into the data. The degree to which users employ known landmarks in their search is in the second study. There is a need to know if user's searches are pre-planned/ intentional, and if this is a characteristic only of experienced users.

11.11 Research on the benefits of using multimedia

Research on the recognition of learning quality in multimedia was covered in the literature review. Research by Beasley and Vila (1992) is especially relevant to my work as they were reviewing navigational patterns, although their concerns were in determining the relationship between navigational patterns and scholastic aptitude, and the relationship between navigational patterns and gender. In their work screen-by-screen information was collected on how the students used the software, but only hierarchical and linear patterns were looked at. Commenting on the students use of the software they stated:

> Learner scores in English were the best predictors of linearity and non-linearity (p.220).

The study showed that lower ability learners in English tended to navigate through the multimedia lesson in a more non linear or exploratory way than did middle or higher ability learners. They also noted that females tended to take a less exploratory approach (i.e., more linear), whereas males followed a more exploratory approach to lesson material. However their results show that lower ability females and higher ability males used non-linear methods. Their research has indicated that there may be differences in preferential choice of navigation patterns through gender. Beasley and Vila concluded that although there were a number of theories and various innovations for helping users navigate through large databases, there is relatively little research that examines the methods of access that users desire to employ when accessing large amounts of information in a multimedia environment. This is one of the gaps that this research will address. Trumbull, Gay and Mazur (1992) in their research on different search modes contended:

> Evidence suggests that many potential users of hypermedia system lack the cognitive skills, the motivation or the attitude towards learning required to take full advantage of these complex systems (p.315).

As in Allinson and Hammond's (1989) work (cf. 3.11) Trumbull et al. found that different search modes affected the amount of information found, with the linear users (i.e. Index users) finding fewer relevant events. This thesis' research will examine users using different navigational patterns and the type of searches they make. However the quantity of information found is not one of the aims of the research, as the research will concentrate on the type of information and the methods used to find it.

11.12 Working Strategies improving the multimedia experience

The fundamental issue is in what ways do working strategies improve the quality of the student's experience? In addition are we able to recognise the contribution of these working strategies in this process? The empirical study addresses these issues in the following way:

1. How much time is taken by different individuals to perform certain tasks?
2. What material is collected in a certain time frame?
3. How varied are the sources that are used?
4. The nature of the work and the strategies performed/used

5. The students own perception of the work done and its quality

One of the research premises that the second study investigated is whether or not a composite search method, using a complicated and sophisticated navigation pattern, was more satisfactory to the user than that of a user who followed a simple navigational strategy. The interviews with the users allowed differences in navigational choice and positive search outcomes to be related.

11.13 Conclusions

This chapter has addressed the issue of working strategies in the context of how people use multimedia. Five working strategy classifications were outlined and compared to those made by previous researchers. The chapter was concerned with identifying the relationships between navigational patterns and working strategies. It considered the role of working strategies in developing the student's experience of multimedia. The outcomes for the first study included the need to develop software interfaces in multimedia for the individual, such as allowing a personalised pattern of work, different levels based on age groups or knowledge level (novice and expert), and extra work for areas of little knowledge or poor performance, relating the working strategies to the user's navigational patterns.

12

Study 1: Lessons

12.1 Introduction

The methods used in the first study were largely qualitative despite the relatively high numbers of participants. Each pair navigated through specific multimedia packages with set tasks, and although there was freedom of movement through the resource, each pair had distinct preferences for how they navigated. The selection of pairs caused some problems in merging or mixing the navigation preferences of the two individuals and it was decided that individuals should be selected for the second study. The other main concern with the first study was that the range of navigation patterns used by the children were restrictive and none of the children exhibited the skills and abilities associated with an expert user. The fact that multimedia was relatively new to them may explain this, however the restrictive range meant that adults were chosen for the second study to expand the potential range of skills and abilities and to allow longer and more in-depth experience of using information technology. The variation between individuals and the need to develop a full classification of the navigation and working strategies would enable the first study outcomes to be the driving force behind the second study. A triangulation approach was adopted using observations, questionnaires and interviews for extracting user's navigational patterns, to ascertain the widest range of navigation patterns and to ensure all the variance within and between the groups is noted. This multifaceted approach was successful in the first study and will be developed further in the second study.

12.2 Relationship with second study research

The first study assessed the packages, indicated the navigation routes pupils used, and identified significant methods of navigating. It assessed the hypothesis that each individual has preferred navigation patterns and working strategies, and found it to be broadly true. Having pairs rather than individuals has complicated the exact patterns and strategies. This factor needs to be changed for the second study and individuals rather than pairs will be observed. In addition the poor audio quality of the recordings has meant that these pairs were difficult to analyse. Therefore better quality and consistency of recording is required for the second study, with recordings made via the computer and each screen recorded, with linked sounds and comments. Despite problems the first study has been informative in developing the research methodology. The second study involved longer sessions for fewer users, and three tasks to demonstrate their preferred strategies.

12.3 Approach to research questions after Study 1

The approach to the research questions after Study 1 was based on two main elements. The first was the investigation of the navigational patterns, initially developed by the children, in order to produce a full classification and allow further expansion of these with an adult group of users. Secondly the relationships between navigational patterns and working strategies were considered. The role of working strategies in developing the student's experience of multimedia was investigated. The outcomes for the first study resulted in the necessity to develop multimedia interfaces for the individual, such as allowing a personalised pattern of work, different levels based on age groups (three different children age groups and one adult group) and to develop knowledge levels (novice and expert) within the software, and linking up with areas of little knowledge or poor performance for each pupil, relating the working strategies with their navigational patterns.

The first study also revealed that better recording methods were needed to allow a timed sequence of screen visits or nodes visited, to be recorded. This would allow a graphical representation of each user's session to be created from the records. These could then be compared across the participant group to investigate group preferences and to compare individual routes within each task and within each set route. Lessons were learnt from the children in the way they preferred to use multimedia, the help they required and in the time it took to complete certain types of task, which were useful in the second study. The main disadvantage of using children in the first study was in the range of skills and abilities as well as the experience that they brought to the session. The children were relatively inexperienced computer users, despite having described themselves as experienced and used to using computer software, this may relate solely to the use of specific games. These may develop their hand eye co-ordination and use of the mouse and knowledge of screen layout, but gave little help or experience in using a complex and graphically structured multimedia environment, without navigational aids such as maps. As the variance between users was a core feature of the information required to assess the navigational patterns it was decided that there was a lack of the full picture produced by the children as their sessions had produced a relatively limited band of skills and abilities.

It was therefore necessary to access a wider user group and it was decided that adults should be the focus of the second study and that the participants should represent as wide a range as possible of the skills and abilities in using multimedia. Using total novices was not very useful in ascertaining their navigational preferences, as they did not gain enough information on how to use multimedia on their own and needed much longer term use. However using multimedia with others (i.e. in pairs) allowed different levels of computer literacy. In the second study each individual adult was recorded in a multimedia session. Issues of the reliability or validity of the study were also considered, and validity had proved to be more feasible, but questions on validity were difficult to answer and would be again reviewed after the second study. Another aspect, which began to be developed from the first study outcomes, was the concept of a continuum of experience, based on skills and abilities, of using multimedia. This would mean that each individual could be placed on the continuum and would gradually move up the continuum (from novice to expert), as they progressed through different multimedia sessions and from exposure to a wide range of multimedia products. The continuum development work was based on a broad definition of a continuum as a horizontal plane where there was continuous evolvement of these skills and abilities from the user's first initial use of multimedia as a novice moving up to their development as an experienced and expert user. A significant finding for the second study was the recognition of the variance between individuals or groups and that it was possible to analyse this variance. The other main issue for this thesis' research is the development of knowledge on individual methods of using multimedia. The recognition of each individual's preferences and method of working would allow the development of preference-based multimedia.

12.4 Classification of Navigational patterns

The following navigational patterns were classified after the Study 1 empirical work, by investigating the observations and also working through the analysis of the patterns used by the pairs, and the review of the research literature (Chapter 10). These are intended as a workable classification, which will then be further tested empirically in the second study. Some of the work on the patterns was made more difficult by the use of pairs, as one of the pair would follow a particular pattern and then this would be changed when the other member of the pair took over control. In other cases the pairs worked more closely together and made joint decisions of where and how they would navigate. The changing over from one pattern to another with some of the pairs was more evident when one of the pair returned to the same method frequently. This was particularly the case with users who preferred to work in a linear or sequential way, and with those who preferred to work hierarchically. These will be further tested empirically in the Second Study (Chapter 15). The list of the navigational patterns is below:

Linear	**Circular**	**Hierarchical**
Linear extra	**Star**	**Hierarchical -Extra**
	Star extra	**Complex - Chaotic**
		Complex -Planned

12.5 Classification of working strategies

The first study allowed the classification of a series of working strategies (Chapter 11). The working strategies listed below will be further tested in the second study (Chapter 16).

Orientation strategy	**Composite - random strategy**
Researching Strategy	**Composite - ordered strategy**
Studying Strategy	

12.6 Outcomes from Study 1

The first study showed there were distinct preferences for certain patterns of navigation, and there were great variations between individuals and between age groups. This shows that there is evidence to answer the main research question. The majority of the pupils used both linear and hierarchical patterns, but in different amounts, and the star and circular patterns were less used. There was little evidence for the use of complex patterns, although the more experienced users were beginning to use different patterns for different tasks and to rapidly change over to other pattern types when necessary. Factors affecting the choice of navigation patterns and working strategies within the younger pairs (primary) were: personal preferences, ability levels, and group dynamics, experience of computers and usage, and confidence.

The younger children were content to browse and search for information, but were less willing to discuss or draw the layout for Task 3. Older (secondary) pupils preferred a task orientated approach, because this mirrored their normal school work, and prevented them from exploring in a freer environment, with some pairs considering unstructured work as time wasting, rather than enlightening. The tasks were more relevant to, and more successfully completed by, the older children.

Simplistic interfaces (e.g. Way Things Work) had definite age limits, and were exclusively used by primary school age children. There was misunderstanding of features. Younger and less able children disliked text, preferring graphics, video, animations and sounds. Primary children preferred activities and enjoyed interactive sections e.g. animating machines (WTW), using facilities for printing, copying text and creating their own workbooks (MR). The design of the package did affect how they navigated through it (the first subsidiary research question), and their method of working, as there was variation in the patterns and strategies between packages. The available patterns were not always easy to understand or to follow, although some e.g. the Timeline in Grolier's, were very explicit. The ability levels of children affected their use and their understanding of the software, as well how the pair operated and the negotiation within the pair. The younger (primary) group found the session difficult even with high ability pairs. The middle group were able to do the session together if well motivated and in the right pairs. The secondary pupils managed this successfully, regardless of pair groupings and did not need encouragement.

12.7 Summary - Main outcomes from the first study

The summary lists the outcomes that will be taken forward to inform the second study. These outcomes have informed the second study and will be incorporated into the methodology. Table 12.1 below lists the main outcomes in terms of the user and designer issues and lessons to be learnt from the first study which can be taken on to the second study.

Table 12. 1 Summary of main outcomes from the first study
Designer issues • The methods used to navigate showed great variation, but often follow set patterns • Definite preferences e.g. linear preference followed a linear path (e.g. Index, Glossary) • Hierarchical and circular/star users common, users who wanted to investigate every section • Some users had complicated patterns and strategies • Navigation patterns within pairs were confused as each pupil followed own selection • The interface was critical for younger children who generally preferred graphics • Younger children found the misrepresentation of areas e.g. Word Search difficult. • Definite cut off points noted for some interfaces, interfaces being too young/ too adult
User issues • Some pupils dislike browsing, preferring task based work, others disliked open tasks • Younger pupils were often unsure what to do and unfamiliar with the browsing concept • Introduction or orientation session/tour needed especially by lower ability users • Children's ability affects use/ understanding of multimedia, amount/ significance of material found, relation to task and how pair operates • Children were deterred by text/ large body of information, did little text reading & preferred graphics, or an intermix of text, graphics, video and sound • Users who were graphically orientated would look for images they liked
Lessons from First Study to be used in Second Study • Navigational patterns and combinations of these for each individual/pair • To change the focus from children to adults for greater diversity of skills/abilities/ experience • To use individuals rather than pairs to determine an individual's own navigational patterns • Differences in how pairs navigated, their perceptions of use & relevance, to be explored • To restrict software to one package to prevent relearning navigating & allow re-use of patterns • To record the session electronically for quality in each screen used, time taken, & comments • To develop the concept of a continuum of experience for multimedia from novice to expert

Part IV
Study 2

Part IV Contents:

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Study 2: Outline

13.1 Introduction

This chapter starts with the relevant factors arising from the first study, which both affect and help to develop the structure for Study 2, such as task information, the amount of time needed for each task, navigation patterns and an analysis of working strategies. The methodology has been discussed in Chapter 7. The results of the empirical sessions and their analyses are reported.

13.2 Outcomes from the first study

The first study raised four crucial issues for the second study:

1. The type and nature of the tasks given to the users
2. The navigational patterns used
3. The amount of work possible within the allowed time and
4. The need to resolve problems with recording the multimedia sessions

The analysis of the first study navigational patterns enabled the development of a classification of navigation patterns, ranging from a simple linear structure through to complex patterns. Most users habitually employed a limited range of patterns. These users were new to multimedia, and their pattern use may alter with longer use of the packages, but more experienced users of multimedia still have preferred patterns of use. It is important to see if the second study confirms the first study findings and whether it supports the hypothesis that most users have a specific (although possibly limited) range of patterns for using multimedia.

13.3 Data collection 1 – Pre/ post testing questionnaires and interviews

As with the first study, both pre and post questionnaires were completed for each user. The pretest questionnaire was completed before the multimedia session. The pretest questionnaire requested information on the user's previous computer/ multimedia and software use, work use, and questions determining topics that interested them and if they had any preferred methods of working through software (Appendix 1). The post-test questionnaire covered the factual knowledge they acquired in the session, and was completed as an interview with the observer and focused on their navigation methods and choices, their reasoning behind these choices and their opinions of the software. The post-test also investigated their approach to using multimedia; identified problems encountered and sought their personal preferences on navigation and methods of working.

13.4 Data collection 2 - Systematic observations

Systematic observations were done for the second study in a similar way to those of the first study with a similar setup, although the observer sat at a different desk behind the user and out of sight from them and had each screen they were using relayed onto a different monitor. In the second study the adult's navigation was recorded via a scan converter onto the computer allowing video and audio recording of routes and comments, linking the screens they visited, to the comments that were made. Observational notes were made while the multimedia sessions were being recorded. Additionally requests for information, or when the user needed help because they had reached a point where they could not progress or had become lost, were noted. The importance of video recording of subjects was commented on by Anderson and O'Hagan (1989) who stated that video records machine/ human interactions, which would be invisible by other methods:

> It underlines the necessity of studying in detail the interactions (human and human machine) taking place at the computer interface. Attempting to evaluate the efficacy of CAL by taking only pre- to post tests change measures would result in our remaining blissfully ignorant of such problems (p122).

13.5 Data collection 3 - Multimedia sessions

For the second study each individual was asked to talk aloud about their movements and this, as well as their timed movements on each screen, were recorded onto videotape by means of a scanner, and paper based observation notes were made by the observer. The scanner version allowed each user's session to be recreated in a timed sequence, with each screen and link they followed reviewable. The initial starting point for the first study had been a pretest, which assessed the children's previous use of the computer. The second study adults had a similar pretest assessment, followed by multimedia sessions and a post-test, with a further interview later.

13.6 Data collection 4 - Second Study Post observation interviews

The post observation sessions consisted of a debriefing interview, when the user's opinions on the session and the software were ascertained. In the second study a further interview, one week later, assessed the user's recall and the information they remembered from their session as well as the method of navigation and the package structure. Although the second study concentrated on user issues, reference was made to the designer issues from the point of view of the software design.

13.7 Data analysis techniques

In the second study each session was recorded in note form and via the scanner, which gave a video image of each screen visited and created a permanent record of each session, together with an audio stream of the user's comments at the specific screen where these comments were made. From this a timed sequence of each user's navigational paths was drawn up as a chart. Further analyses were conducted on these charts looking at individual paths, identifying the individual's paths through each of the three tasks, all the paths for a specific task, and groups within the users, such as novices and experts (cf. Chapter 14). This allowed further work to be completed on the grouping of individuals across all the users in the research. The working strategies used were also analysed and these were classified into types. Other elements were investigated such as the tools individuals used and the types of searches that were performed.

13.8 Data analysis - Visualising and analysing navigational routes

The navigational charts were the main method of comparing the individuals and the groups and an annotated example is included at the end of the chapter (Chart 13.1). These navigation charts were developed from an analysis of the component elements of the Encarta package. Once these had been divided into the specific resource and specific feature (e.g. tools) areas, a chart was created. From this background chart it was possible to superimpose a graph of the user's movements through the resource. This graph represents the time spent in each area and the amount of movement through each part of the Encarta package. From the timed scanned sequence it was possible to link the time spent on specific screens with the tools used. A separate graph was prepared for each user and for each task. The three task graphs for each individual were then superimposed onto the same chart to give the full navigation chart for each user (Charts 15.1 – 15.20, in Appendix 3). Further work was done on the individual graphs for each task and from these specific individual graphs, it should be possible to analyse group characteristics in navigation. These charts were created in order to give an indication of how the users progressed through time, where they went in the package, and which tools or special features they used, and to ascertain if they had any set patterns in how they used the software. The charts demonstrated links between the different groups of users (such as the novices), links and comparisons between the tasks, and individual's performance in all the tasks, as well as being able to compare each user's paths.

13.9 Data analysis – Matching navigational patterns with the classification

Once the navigational patterns of each individual had been analysed from the navigation charts and the observation records, these were then matched to the navigation pattern classification developed after Study 1. The adults in Study 2 used a wider range of patterns and were generally more adept and quicker at both using patterns and in changing to more suitable patterns as needed.

13.10 Data analysis – Topologies of the multimedia packages

It was important to be able to identify the different structures within the multimedia package and to be aware of the design features within these packages and also how it was possible to move around through the package. For example the Peanuts package was designed for children but it had a very simplistic linear structure and it was necessary to go through specific screens in a set order to arrive at a specific task, hence the designers of the package had a high level of control over what and where the user could navigate. The topologies of two of the packages, Grolier's and Encarta were very complex, Eyewitness History had a great number of different screens but comparatively little depth in any one area and Medieval Realms had a great deal of depth but was hierarchical in structure. The topologies were then matched to the navigation patterns and created as overlays so that the navigation patterns could be easily viewed on the structure of the multimedia packages.

13.11 Data analysis – Verification of the navigation pattern classification

After the navigational pattern classification was tested after Study 2, it was considered necessary to further test this pattern series with an expert panel assessing the series and comparing my series with those of two other researchers. The expert panel would verify the pattern series and give a critique of how useful and appropriate the pattern series would be for multimedia.

13.12 Hypotheses, research questions and expected results

The outcomes from each of the tasks are expected to produce overall trends, but it is expected that the most significant effect will be different for each task, as the outcomes will reflect the type of information and the nature of each of the individual tasks. As the tasks themselves will be performed by relatively small numbers of people the outcomes will indicate trends and be used to investigate the following hypotheses. The bracketed numbers refer to the first and second studies and the task number in each case (First study tasks 1, 2, 3 are F1, F2 and F3, Second study tasks are S1, S2, S3).

Hypothesis 1 -That each individual has preferred methods of using multimedia (F1, S1)

Hypothesis 2 -That certain navigational patterns are more successful for the user than others (F2, S2), that these can be re-used (S3) and more experienced user's patterns can be taught to less experienced users (S3)

Hypothesis 3 -That navigation patterns can encourage in-depth searching and potentially deeper working (F3, S3)

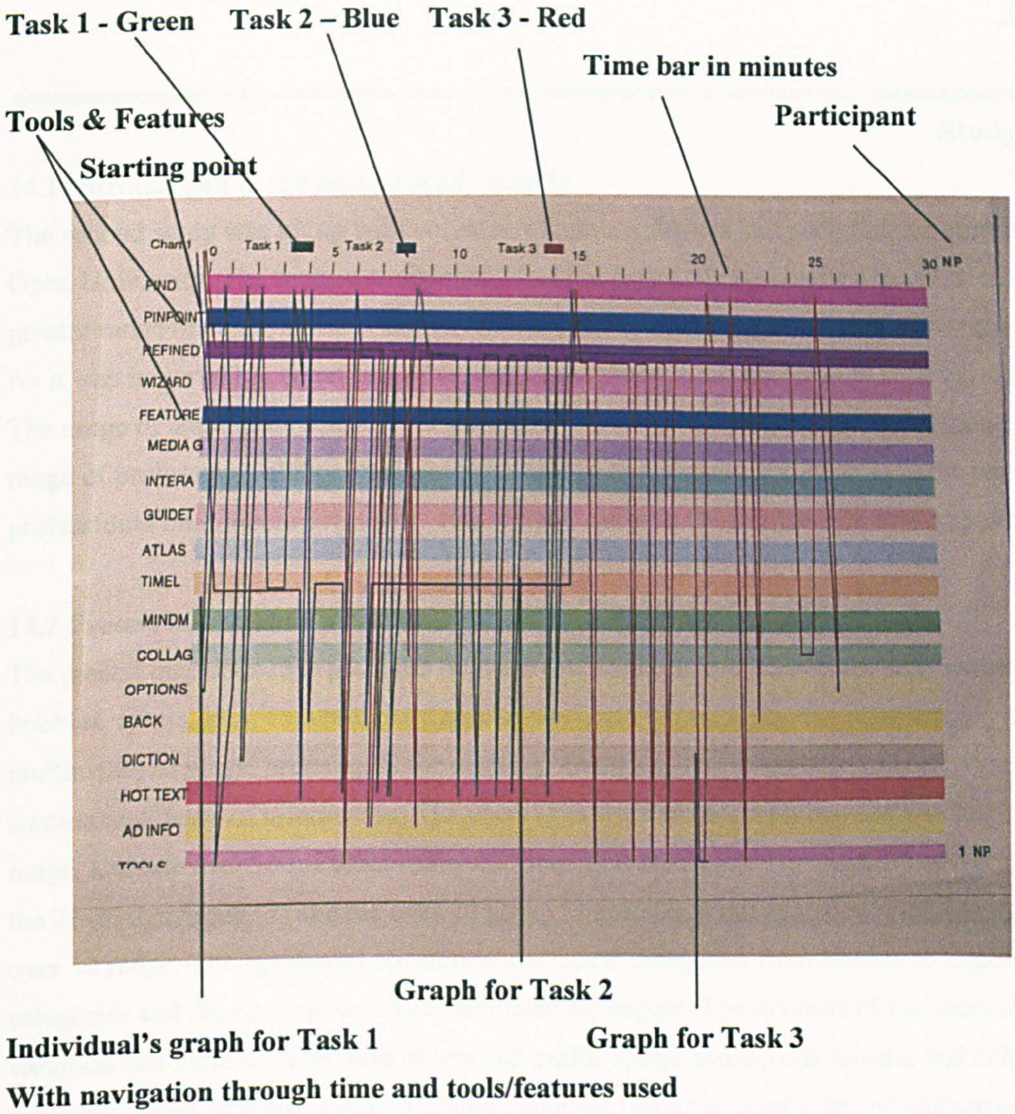
Hypothesis 4 -That experience of multimedia or controlled use can enhance the usage of multimedia (F2 & S2 and S3)

These hypotheses will be analysed in the following discussion chapter, which also includes further analysis of the second empirical work. Hypotheses 1 and 2 relate to the user perspectives, Hypotheses 3 and 4 are relevant to the designer perspectives, while 1 is applicable to both.

13.13 Conclusions

The empirical work software needed to be easy to use, require little instruction, and not require developed techniques to exploit it, as the range of users was from novice to expert. Commercially available packages were used as these fulfilled most of these requirements. Commercial package designers are also becoming aware of the needs, addressed by this research, of the individual user. The methodology proposed for this thesis' empirical work reflects the need to investigate designer issues, so the first study investigated users working through a series of software packages, in order to elucidate specific user preferences. The second perspective – the user issues, are covered more in the second study, where individual users are investigated completing several tasks in the same software. This examined if they always used the same patterns, or if they used newly discovered patterns and if they were able to re-use earlier navigation techniques in their own research areas. The User and Designer perspectives are used to link back with the research questions in the discussion chapter. The necessary link between the two perspectives, designer and user, has been highlighted in the first study as both designers and users contribute to computer programming and the creation of multimedia. This division is crucial as the designer's perception has been that the user need not be involved in designing or using the multimedia until the package is complete.

Fig 13.1 A Navigational patterns chart and an explanation of the component parts (The navigational chart for each user is in Appendix 3)



The chart above (Fig. 13.1) outlines the navigational charts and gives an explanation of the component parts of the chart, the navigational charts for each user are in Appendix 3.

The need to involve the user and their navigational preferences should be included at the initial concept design level or stage. The software usage is demonstrated by the navigation patterns and the range of methods used serves to demonstrate the necessary complexity of multimedia navigation. The range of novice to expert is well known but the navigation patterns range seen cannot be simply represented by this and the subdivisions are significant as these relate the pattern selection to stages in the user's comprehension and their development of navigational abilities. Few multimedia packages allow this flexibility. Showing that this range (or continuum) exists is important and should enable software designers to cater for a range of users not just broad divisions. If multimedia prototypes were fully tested in this way it is possible to build in the range of navigation patterns required by the user, which would make much better and more individually adaptable software, a core component of modern programming.

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Study 2: Results

14.1 Introduction to the Second study results

The second study was set up with volunteers from employees and postgraduate students at the Open University. The focus was changed from the first study on children to adults to allow a greater range of skills, abilities and experience, and a more complete range of navigation patterns. As it was important to determine each user's navigation, individuals were selected rather than pairs. The range of adult users selected for the study was necessarily broad and encompassed a whole range of professions, ability levels and knowledge of computer software from the beginner to the professional multimedia developer. This chapter outlines the results from this empirical study.

14.2 Pretest information

The pretest questionnaires provided relevant user information. It covered: their interests or hobbies, sports, jobs, computer hardware at work and home, computer software they use, the multimedia used and preferences for working strategies. The responses were very varied in the amount and detail of information. The users ages were varied, with two users in the 20-25-age range, and one over 50 (of those users who specified their age). The majority of the users were in the 26-29 age group (7) and the over 40 group (3 definite, 4 not specific), with 3 in the middle, over 30 range. The age spread covered all the users' categories from Novice to Expert, and all job categories and did not appear to have any specific impact. The interests of the users showed wide variation and included a mixture of arts and crafts, sports and outside leisure, and cultural activities. Areas of interest were grouped under the headings: hardware and software previously used, knowledge levels, and interests and working methods. Finally, users' previous strategies for using multimedia and any problems associated with the sessions were covered.

14.3 Hardware and software previously used

Some users had experience of both Macs and PCs, but individuals usually preferred one particular type of computer. The software used by the users was frequently with the same, or similar packages, as most users employed Word, E-Mail and more occasionally Internet Explorer or Netscape. A few users were familiar with Excel, SPSS and First Class, and databases or student files. The more computer-orientated users were using graphics and authoring or programming software and usually needed to use computers for their professional work. The relative lack of use of multimedia amongst members of the whole group was surprising: few users had extensive experience of multimedia, although several users had tried various software packages. This was reflected in their own classification about their level of expertise, where most users regarded themselves as Novice or Intermediate level, with only three users as experienced or Expert.

14.4 Task analysis

The tasks were analysed using the observation session notes, the individual's navigation charts, and their comments. The observation session recorded each screen the user visited and how long they spent on it with the movements through the screen and any links. From this it was possible to create a navigation chart, which consisted of a timeline divided into minutes and each area of the multimedia package. It was possible to plot each route through each task and then to relate these for each individual and then for each task and the specific routes. From this analysis and from the pretest questionnaire results it was possible to relate the navigation patterns with the three groups, novice, intermediate and expert. Comparing the graphs allowed a further subdivision into the sub-groups. Analysing the session comments and the interviews after the multimedia session allowed an estimation of the working strategies used to be made and an analysis of the search methods.

14.4.1 Second study, Task 1 - Browsing Behaviour

Most of the users started by checking the lists of features and selecting particular features to try out, which they continued to do for some time, occasionally exhaustively. All the users employed Find and Pinpointer, but there was little dictionary or help system use. Particular users had preferences for following links and selected this option whenever available, with similar preferences with some users with the Related Articles feature. The use of a linear pattern was common initially with all users, but especially apparent with Novices. A linear pattern was frequently used for initial investigations, before more specific patterns of navigation. Generalised browsing with no commitment to any particular route was fairly common initial behaviour.

14.4.2 Second study, Task 2 - Set Task, Roman Empire

The second set task, where the users followed preset routes through the Roman History area, demonstrated varying degrees of interest in the subject. Opinions varied from finding the subject matter very dry and text based, to others who found the subject content engrossing. It emphasised the real Expert users who managed to assess it quickly, as well as the complete Novices who were unsure where to start or how to approach the subject and wanted exact instructions. Total control over the users' routes would have prohibited any self-choice within the task, which was one of the elements that this thesis was investigating. The four user routes through this task were deliberately set with different degrees of user control, ranging from purely linear to less controlled routes until the last option, which allowed the user to select required options from a topic list. In the latter case, the order in which they investigated the subjects and the actual selection of them (from a topic range within the subject) was at the user's discretion. The Novice users found the freer choice options difficult and a few users totally disliked the subject matter, which was not positive for the task outcomes. The set task encouraged a great deal of rapid skimming/ browsing, which was probably augmented by the large text content. Relatively few pictures were used and in most cases the text was rarely read fully, or read more than cursorily. A further issue was that the high text quantity may have encouraged a hierarchical route, with the user selecting this navigational pattern to cope with the text volume rather than as a method of navigating the resource.

14.4.3 Second study, Task 2 - Outlines of the four different routes

The four alternative routes for the Second study Task 2, each of which has increasing levels of user control, are now described. These routes have been labelled A, B, C, and D. The A route was very linear and allowed little movement across the resource. Route B was hierarchical and allowed a little more freedom of choice for navigation. Route C used the Find Wizard and Route D, the Open Route, allowed the most choice of the navigational routes through the same material.

a) Second study Task 2 - the Linear route using the Timeline, Route A

Users on this route either followed the complete route until they had finished, or missed sections, in spite of the fact that it was a very simple and linear route. However major areas of the subject were always covered, i.e. completed by all users, and the majority of the users were enthusiastic and interested in this route. It involved very short pieces of text and a reasonable amount of graphics, but also a lot of movement backwards and forwards between items in the Timeline. This enabled the users to see the text in relation to a historical context, and to divide up the task into a number of short sections. However some users were still off task or, rather, took detours off the prescribed route. These detours were often still in the Timeline, and indicated either that the user was interested in other topics or that they wanted to orientate themselves historically. The users' comments on the Timeline were that they benefited from these off route detours in that they placed the Roman material in context with its historical period and events. Examples of the topics that frequently encouraged this off route behaviour were the Silk Road, Egypt and Antony and Cleopatra. A few users were frequently off task, suggesting they preferred their own selection to the prescribed route, or as with other routes, they were totally disinterested in the subject area.

b) Task 2 - Second study - the Hierarchical route, Route B

The hierarchical route had the heaviest straight text component. This was commented on by several users, and described as: 'daunting, dull, just all text'. All these users who commented on the textual content were rapidly bored, and those who were aware of this at an early stage, explored other routes more rapidly. The text was difficult to read and was historically rather than culturally based, with information on wars, emperors and dates rather than more easily digested social/ cultural material. There were users who checked all relevant areas and then went back over certain sections and were very thorough. This perceived need to go back over and reassess what they had already covered was a very common practice. Some hierarchical route users were unsure about how the task could have been improved but other users wanted an even more specific set task, with a series of questions to answer. Setting a more specific task would have affected their navigational route choices and have made every Route B user follow the same route.

c) Task 2 - Second study - using the Find Wizard, Route C

The Find Wizard route allowed more self-selection of the individual subject areas within the broad range of the specified Roman areas. A few of the users felt there was rather too much choice, as they had to decide what to choose, and thought it would be better to narrow down possible choices.

There were also comments on the vast amount of information and that it was far too detailed. Several topics were very popular such as Art and Architecture, and certain users spent most of their time in this area. They were initially encouraged to look here and in History of Rome, most users followed this advice and started in this area. Although a lot of the actual text used was also similar in nature and density to that of the second route, there was more flexibility within the task. This meant the users were less bored and disinterested, as they were able to find another area that they were interested in when they became saturated with the historical side. There was less off task time although there was off subject work, but the users usually stayed within the Find Wizard. A problem with the Find Wizard was that it was not restricted to the prescribed time range, for instance in the period 500 BC - 500 AD, subjects such as the Middle Ages and the Goths were included, with nebulous links to the time zone. Several users visited these two areas, as they were surprised to find them included. Arguably the date specification option on the Wizard should be refined. The areas outside the main Roman subject that were most visited by the users included: Latin Literature and Homer, Middle Ages, and Byzantine Art and Architecture. A few users spent a large proportion of the available time in these very peripheral topics. One of the Novices found it difficult to know what to do. In retrospect this was a rather daunting route for first time multimedia users, although it worked well for the more experienced users.

d) Task 2- Second study the Open option - Route D

The Open option to the navigation routes allowed the most user freedom. Although they were asked to research the same broad subject area they were not given any direction about how to do this, apart from the list of available topics on the subject within Encarta. This open method led to the users selecting very varied routes within the material. Each user's route was different, although they covered broadly the same or similar sets of material. There was a degree of overlap between each user's chosen route although the topics were covered in a different order, and with varying time spent in specific topics for all five users. There were comments on the large amount of text to read, and some instances of off task work. However although these detours were considered off task, the users were usually following links from the material, and so were within the same subject area but not in the prescribed list of topics. The comments on the features/tools used were productive for this route as the users had free choice and frequent use of the Timeline by four Experts and one Novice. Out of those five users, two Experts used it a great deal. The Famous Buildings collage was popular but despite having some links to the subject, it contained a lot of information outside the subject area. This prompted one user to state that there were design inadequacies in all the collages, as the user was not taken to the specific point within the collage, but expected to find it themselves. Comments on the software design were also made regarding the screen layout. Again there were extremes of responses with users either being very enthusiastic about the subject matter or not interested in it at all. The open nature of Route D caused one user to suggest that a more specific focus for the search was needed, as well as better searching methods or tools. The second task was very helpful in determining the user perspective, as each user followed set patterns and the amount of adherence or divergence was a significant indicator of each user's working strategies. The specific route preferences of each individual and how, and if, the enforced patterns were re-used in the third task were also revealing. There was greater variation in the third task, although there were some similarities. This task often enthused people who were able to follow their own subject matter or interest. Prior knowledge was noteworthy in this task as most users selected subjects they already knew. Some users when re-investigating a subject started by returning to previous task results. Usually there was a catalyst for this, e.g. a topic had caught their attention earlier. The open task may have been faster to perform and possibly more naturalistic if the users had been asked to previously select a topic to search on.

14.5 Further analysis of Task 2 – Study 2

Further analysis of Study 2 task 2 was done, especially in terms of the working strategies that were used. It was decided to do a timed sequence to ascertain how long individual users stayed using the same strategy. A timed analysis of this was done by working back through the observation tapes and constructing a chart of the timed sequences. This was to decide how much of any particular strategy was used and what their range of working strategies was in that task. More work was also done on the search methods. I decided that it would be better to amalgamate the search methods and working strategies and to combine the attributes into an integrated series of strategies. These strategies were linked to the navigation patterns as different users had specific combinations of both. However from Table 16.3, most users used Orientation, Researching and Studying strategies although the Orientation strategy was used briefly at an initial stage and the other two Researching and Studying, were the main method of searching or working. The exact choice would be dependent on the user although most users employed both strategies. This may represent the use of specific strategies for particular parts of the task, and the timing and amount of time in the strategy were based purely on the user's preferences. Further information on the analysis of Task 2 is in Chapter 16. Table 14.1 (overleaf) gives the navigation patterns used by each participant and the task they used them in.

14.6 Types of User: Novice, Intermediate and Expert

After analysing the pre-test questionnaires and the empirical sessions, three main types of user were classified. These were classified as Novice, Intermediate and Expert. The novice to expert classifications were based on the information supplied by the users and their knowledge of software and in particular multimedia. The participants in the second study were volunteers from the Open University and covered a large range of job functions. The expert users were multimedia designers and computer scientists. The intermediate users were people who had some knowledge or use of multimedia but were not as expert as the professional users and usually did not use or create multimedia in their work. The differences between the novice and experts in the literature review have been described by the core researchers for this thesis such as Horney (1993, who only investigated experts), Canter (with Powell, Wishart and Roderick, 1986) and Oliver and Oliver (1996), who were all looking at novice and/or experts using hypermedia. The methodology chapter has covered Brown's differences between ordinary and expert users.

All these researchers have found differences in how novices and experts use software, in terms of their speed of use, the ability to change patterns or strategies and the skills used such as knowing when to finish searching and how to recover from an abrupt end. However within this range there was immense variation. Finer subdivisions are possible, based on the user's knowledge and computer experience generally and with multimedia and evidence for this has been found in both the individual patterns and the working strategies. Subdivisions of categories were considered:

High Expert	Very computer literate, very multimedia literate
Low Expert	Very computer literate, slightly multimedia literate
High Intermediate	Computer literate, slightly multimedia literate
Low Intermediate	Computer literate, not multimedia literate
High Novice	Slightly computer literate, not multimedia literate
Low Novice	Not computer literate, not multimedia literate

The use and relevance of these potential classifications will be explored in the discussion chapter. The simpler division into Expert, Intermediate and Novice has been used for the second study analysis to see if there are any broad traits or specific navigational patterns for each group. It was felt that higher numbers of users (more than the twenty of the second study) would be needed to explore the further sub-division of these groups, which was not possible in this thesis. A key point was that each individual's status of Novice to Expert was not the most crucial factor in determining their navigational pattern preferences, and so further subdivision was not considered necessary at this time, because the navigation pattern preferences were spread across the novice to expert categories. The only exception to this spread was in the Complex navigation patterns and Composite working strategies, which were mainly used by the experts. It is possible that the spread of the navigation pattern usage in particular represents some development of the skills of the user and is therefore more of a continuum, with certain patterns being used by novices, intermediates and experts, but with experts able to use all the navigation patterns as required. The opposite, that novices use a limited range is true, although the case for the intermediates is less clear.

14.7 Conclusions

The results chapter conclusions for the second study are that individuals have both distinct navigation patterns, (Chapter 15), and definite working strategies (Chapter 16). The change of focus to adults rather than children in the first study was successful and each adult member demonstrated a greater range of patterns. Individual assessment of individuals was valuable, as this enabled their specific use of patterns to be determined. From this information navigation charts for each individual's progress were created through the software package and for each task. The working strategies used were investigated in depth. From the questionnaire analysis, navigation patterns and working strategies, the participants were placed into three distinct groups – novice intermediate and expert. This proved to be an interesting exercise as some individuals were in different groups for each task. This supports the concept of a continuum of skills and abilities in multimedia and strengthens the proposal that each individual is at a different stage on the continuum.

Table 14.1 Individual users and their use of navigational patterns in each task

Navigation	NP			EH			UP			KS			NL			CO			NT			SX			JP			Users
Pattern	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Total
Linear	√	√		√	√		√	√			√	√	√	√	√	√	√	√		√			√		√	√	√	9
Linear E										√									√		√	√						3
Circular																										√		1
Star							√												√			√			√			4
Star E									√										√		√				√		√	3
Hier.	√	√		√			√	√		√		√	√	√	√	√	√	√	√	√	√		√	√	√		√	9
Heir. E	√									√												√			√			4
Complex.Ch			√																									1
Complex.Pl			√						√									√			√			√				5

Task 1, 2, 3
Each column lists each participant's use of pattern
√ denotes use
Experts top table
Intermediates & Novices bottom

Navigation	OE			BI			JE			QG			TE			BT			JX			DE			KN			IT			QB			Users
Pattern	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Totals
Linear	√			√	√	√	√	√		√	√	√	√	√		√	√	√		√	√	√	√	√	√	√		√	√	√	√	√	√	11
Linear E		√											√						√									√	√		√			5
Circular							√																											1
Star								√	√	√				√	√	√																		4
Star E																																		0
Hier.	√			√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√				√	√		√	11
Heir. E																				√	√					√								2
Complex.Ch						√																												1
Complex.Pl																																		0

15

Study 2: Navigation patterns

15.1 Introduction to the Second study Navigational patterns

This chapter details the navigation patterns of each of the individuals in the second study. The series of navigation patterns was developed from the first study and the literature review. The classification of patterns was related to those found in the first study except for certain navigation patterns e.g. complex ones and developed patterns e.g. hierarchical extra, which were not found within the children's multimedia session. The second study was refocused on adults to allow an expansion of the navigational patterns range. This would demonstrate that the full range of patterns had been recorded and to test that all the classified pattern types had been employed.

15.2 External influences affecting navigational patterns selection

The navigational patterns used by the adults in the second study were generally more complex than those of the children in the first study. These pattern preferences are detailed in 12.13, but there were external influences that may have affected the navigational patterns:

1) **Gender differences,** all the Novices were female, and all the Experts were male. It is possible that the different sexes approached the tasks differently.

2) **Education/IT Knowledge differences,** most of the Experts were working in computer or software design jobs. This affected how they approached the session especially with regard to their scientific background, their familiarity with computers and their use of the multimedia software.

3) **Job differences,** the Novices tended to be secretaries or computer technicians and there were few of these users with university or scientific backgrounds. They would be less familiar with multimedia and would not usually complete this type of work in their normal work environment.

4) **Age differences,** the Experts were usually older and more experienced computer users.

5) **User confidence,** the Experts were prepared to try things out. However the Novices were less willing to do this, for example when asked to change disks, the Novices were hesitant and so this affected what they looked at and not changing disks affected what they could do.

This selection of features by whether they were located on the same disk was particularly noticeable with the small number of users who had to use a slower machine. Due to the lack of availability of a faster multimedia machine, a slower machine had to be used for four sessions. This was found to have a detrimental effect on the free choice of navigation patterns as changing disks took up comparatively greater amounts of time, and therefore highly interactive or graphic features (on another disk) took longer to load and present to the user, and so were only used when absolutely necessary. Tools and the techniques used in the multimedia session were often related, and the tools usage became an essential part of the search, but the skill in using these was variable.

This variation may also have affected navigation patterns as the slower machine speed may have caused an elongation of the patterns. However researchers (notably Light and Littleton, 1997) who have investigated using slower computers have proposed that slower machines allowed more cognitive time and therefore fewer errors. Light and Littleton's comments related to users using multimedia, but they were analysing the methods users used to complete specific tasks and the student's work plans, rather than navigating through the resource. However they argued that using a slower machine could encourage a more structured plan by the user of what to do next. This planning element may have reduced the negative effect of using the slower machine, in that the user thought more carefully where they wanted to navigate and which tools or features to use.

15.3 Individual user's attributes affecting their navigation choices

Navigational patterns were influenced by individual user's specific attributes. These included their level of expertise, and whether the user remained within their own previously acquired knowledge or investigated new areas. Members of the Expert group seemed to be more aware (or more rapidly aware) of unsuccessful searches and were prepared to abandon it. It took longer for members of the Novice group to reach this stage, although there were individual variances. A small number of users re-used techniques they had already used, and this was especially true in Task Three. There were common links across all the users such as repetitions of the same subjects being searched for, which often occurred at the same or similar points on the route. This was probably caused by being off task or by boredom. Most users were prepared to do the set route for a certain time where there was a curiosity factor as to what was going to happen. There were different tolerance factors and some users either stopped doing the search or left the prescribed route more rapidly than others. The awareness of time constraints, such as how much time they had left and how best to use restricted time for searches varied considerably between individuals, from being very aware and asking how much time they had left to others who continued searching until they ran out of time.

15.4 Group navigation patterns

The navigational routes of each group were then investigated: Novice, Intermediate and Expert. In particular the analysis looked for similar features of navigational behaviour within each group and differences between the groups. The first empirical study raised the question as to whether the user's level of expertise was an essential factor in determining their preferences in navigational patterns. A key point demonstrated by the second study results was that although expertise is a contributory factor to the navigational patterns choice, it is not the only or the most significant contributory factor. The navigational patterns were analysed by looking at the sequence of nodes/screens visited, the amount of time spent on each screen and where the user moved at each decision point. From this analysis it is clear that most users used a linear and a hierarchical pattern at some stage. The novices used a smaller range of navigation patterns, and this supports the earlier findings in the first study of only a restricted range of patterns. The experts used a much wider range of patterns and were the main users of complex patterns. The route the user navigated in the first task – the browsing task and how they navigated in the controlled set task were compared.

The third open task was then compared with these routes. These routes were then transferred to the navigational charts (Charts 15.1-15.20), where each of the three patterns for each user was graphed. The individual patterns for each task were analysed into the group classification (Table 15.5). This may relate the users back to the finer divisions of the three broad novice/ intermediate/ expert classifications, which were proposed earlier (in 12.12 and further developed in 12.14). Similarities across the expertise groups and between all the users were noted, as well as comments from the users on methods that they had used to navigate through the multimedia resource.

15.4.1 Novice group (7 users)

The Novice group in the second study on the whole covered much less information, their routes were shorter and less varied, and they were more hesitant than the other two groups. Their navigation methods were often linear, at least initially, but later in the search they often followed a Hierarchical pattern or occasionally a Star pattern, and often went into the next layer (depth) of material rather than remaining on the surface level. Novices all used linear and hierarchical methods, although a few of them were very linear in preference, with little hierarchical searching. Table 15.1 (overleaf) lists each of the individual users in Study 2 and the navigational patterns that they used, while Table 15.2 (2 pages overleaf) lists the main combinations of navigation patterns used by the novices, and their patterns. The Novice group repeated more than the Experts. A few Novices were very wary of re-checking what they had already covered, believing (in the post test interview) that they had seen everything. They usually liked features such as the Timeline. There were no complex users in the Novice group, as they relied on much simpler forms of navigation.

Users admitted that they were not very computer literate or experienced in using multimedia; some worried about mistakes, and expressed the need to re-use the package before feeling confident. One Intermediate group member also shared these comments. Interestingly a few users reused the main method of search from Task Two into Task Three, for example the Timeline. Amongst users generally there was a willingness to change route, but this was unusual for the Novices except for more computer literate Novices. There were others who needed help and advice, four Novices were uncertain of the open task and suggested that a more specific task was needed. Novices needed exact instructions and read them, unlike the Experts, who only needed a basic outline. There were definite distinctions between those who were and those who were not interested in the content of the task, demonstrated by comments like 'discovered information for personal use – otherwise no point', despite the comment the user continued with the task, even though it was not relevant to her, covered a lot of ground and thought that she had covered most of the features. The Novice users were generally impressed with the design and contents of Encarta, although one was not. Software comments from the seven novice users included disliking the red highlighting colour, the collage should be context sensitive on entering it, and there was too much text.

Table 15.1 Individual users and their use of navigational patterns

Navigation Patterns	NP	EH	UP	KS	NL	CO	NT	SX	JP	OE	BI	JE	QG	TE	BT	JX	DE	KN	IT	QB	
Linear	√	√	√		√	√			√	√	√	√	√	√	√		√	√	√	√	**16**
Linear Extra				√			√	√						√		√			√	√	**7**
Circular												√									**1**
Star			√				√	√	√				√		√	√					**7**
Star Extra			√				√		√												**3**
Hierarchical	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√		√	**17**
Hierarchical Extra	√			√				√	√												**4**
Complex - Chaotic	√									√	√										**3**
Complex - Planned	√		√			√	√	√													**5**
Totals	**5**	**2**	**5**	**3**	**2**	**3**	**5**	**4**	**5**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**	

Experts (NP – JP)	**Intermediates** (OE – JE)	**Novices** (QG – QB)

Table 15.2 Navigational styles of novice group classified in the combinations used

Navigational patterns Used	Novices using these
Linear – strong preference, small hierarchical use	IT, QB
Linear and Hierarchical patterns	TE, JX, DE, KN
Linear, Hierarchical and Star patterns	BT
Complex patterns	None used

15.4.2 Intermediate group (4 users)

The Intermediate group in the second study was more varied in their behaviour than the Novice group. They also used linear navigation methods initially, but were more prepared to try new routes and were not worried about making errors. They often were less well prepared than the Expert group and had more random pattern use, and they usually liked hot text links. Even though the group was small (four users) each used a different method of navigating. This was an indication of the diversity of the group and the different levels of skills and abilities within the group. There were differences between those users interested in the task subjects (in Task 2 in particular) and those who were not. Intermediate users also frequently checked back to make sure they had covered all the correct sections. The users on the slower machine stated that it had affected their navigation. They had made choices in their routes to limit the amount of time taken while searching. As a result they selected fewer interactive features, which definitely affected their preferred use of the package and hence the navigation patterns they had used. Most of the Intermediate users were prepared to change direction if their route was not working. Again, as with the novices, a few users reused the main method of searching. One Intermediate user reused the Find Wizard again for their third task. Among the software comments, one user was critical of the package, the features liked included the Timeline, one comment stating that Task 2 was too open ended and that they would have to use the package a lot before being able to get the most out of it. Different combinations of the navigation patterns used by the Intermediates are listed (Table 15.3).

Table 15.3 Navigation styles of intermediate group classified in the combination used

Navigational patterns used	Intermediates using these
Linear and Circular	JE
Linear and Hierarchical	OE
Linear, Star and Hierarchical	QG
Complex and Hierarchical	BI

The intermediates are interesting as the range of pattern combinations is extending and shows how the group can be spread along the continuum from the novice to expert classifications, with JE at the beginning of the intermediates, and BI being placed near to the expert classification. They adapted the search if they did not find any suitable material, and were faster at realising this.

They were also more prepared to branch out and try different areas, except for those with less multimedia experience.

15.4.3 Expert group (9 users)

The Experts in the second study were either complex users or used a combination of the linear and hierarchical patterns. The Expert users were faster, more confident, and covered a lot of ground rapidly, although they frequently did not read instructions, and could become sidetracked.

Table 15.4 Navigation style combinations from this thesis' classification, used by Experts

Navigational patterns Used	Experts using these
Linear and Hierarchical users	KS, NL, EH, JP
Complex users	NP, SX, NT, UP, CN

Expert users used complex methods of navigating, often employing several patterns in one task. Table 15.4 lists the combinations of navigation patterns commonly used by the Expert group. There were interesting uses of different patterns with the tasks e.g. one Expert used complex patterns for Tasks 1 and 2, but hierarchical searching for Task 3. Experts generally decided on an initial path and adapted it if necessary. This was significant, as the Novices largely did not, or could not, do this and this affected the time the Novices spent searching for information. The Expert users had strategies available immediately at dead ends and all the Experts said they had prior knowledge of the subjects they had visited. This may be a confounding factor, in that prior knowledge may affect how the user navigates through the topic, but some prior knowledge of the topics chosen for the browsing and open task was common amongst all groups. The experts were concerned with how they had used the software, with one only browsing superficially, while another was concerned about his lack of recall in the follow-up session. The Experts produced a lot of comments on the software, both during the observations and in the post-test interview. The amount of comments was more than those from the other groups, which was not surprising, as most of them were computer specialists. The software comments covered issues such as: poor scrolling, poor links quality, and too few links, but this was balanced by one Expert, who considered that the hot text links were good. The users stated that a history would be informative, that there was too much text, and that the Pinpointer or search tools generally were not sophisticated enough for this amount of information. Comments were made on the individual features they liked, such as the game, Find Wizard, and the Timeline, with criticisms of features such as the collages, the absence of explanations for the Find Wizard, that the Timeline was confusing, and that more video sections were needed. Several users commented on the problematic red highlighting. Two Experts could not assess if they learnt anything new, while another thought it a useful package but had no depth. One Expert user was surprised at the general poor design and at the lack of feedback, but two Expert users were more impressed than they had expected to be.

15.5 Development of Groups using the navigation charts from each task

Individual charts representing the navigational patterns of each user and for each task were then developed and analysed (Charts 15.1-15.20, in Appendix 3) and these revealed different features:

- Users who used different routes for each task
- Users who always used similar methods for each task
- Users who used either more or less sophisticated techniques, than was usual for their group (suggesting they should have belonged to a lower or higher group)

Although it was decided not to divide the users into more than the three Novice, Intermediate and Expert groups from the point of view of their experience and skills, there were some definite distinctions between the types of navigational pattern that each individual produced. Analysing the patterns for each user for each task revealed pattern preferences, which cut across the basic three-way division. Hence although certain patterns were usually indicative of specific groups, some of the patterns presented made it difficult to classify all three of the user's patterns into one specific group. Different pattern types were sometimes represented in the graphs for the same user. This has meant that the individual patterns for each user were classified into groups. The Classification of groups table, (Table 15.5) lists the charts for each separate task and subtype of the user.
The analysis of the individual patterns relates well to the analysis of the user's working strategies, but these again did not always conform to what was expected in terms of Novice to Expert divisions. The analysis of the graphs indicated that there was a sequence to the types of route taken and these can be placed along an evolving continuum. Three main points came out of the graph analysis (cf. Table 15.5):

1. Certain types of searches were more characteristic of certain groups than others.
2. Each group had shared features, but all members did not conform to every group aspect.
3. Users learnt from their experience of using the package and this affected their second and third tasks, which in turn affected the subsequent chart produced and its classification.

Some users benefited more than others from this learning experience. Routes that were more distinct from the group as a whole were simply a more developed version and were therefore slightly further along the continuum; this could explain the difficulties in the classification process. It implied that the continual evolution of types could be a more practical way of analysing them, rather than producing stricter, rigid divisions, as is required for a formal classification. It was more constructive with the available navigation charts to initially produce broad classifications, and to explore these in the future with a larger sample. This would indicate if there were pattern ranges between the set groups, or if the majority could be fitted in to the broader classifications.
Finally on navigation patterns in this chapter there was evidence to suggest that certain tasks encouraged specific patterns of navigation. For instance the browsing task – Task 1 encouraged a linear or circular pattern, or in some cases even a star pattern and rapid searching. The search Task 2 encouraged hierarchical pattern use and Task 3 encouraged hierarchical or complex patterns, as users covered many areas of the resource looking for relevant information and synthesizing it.

Table 15.5 Comparison of Second study users – Classification of groups

Task 1 **Task 3**

Group 1	Group2	Group 3	Group 4	Group 5	Group 6	Group 7
KN - Novice IT - Novice OE - Intermediate KS - Expert CO - Expert NT - Expert	JX - Novice DE - Novice NL - Expert BI - Intermediate SX - Expert	EH - Expert SP - Expert JP - Expert	TE - Novice BT - Novice QB - Novice JE - Intermediate NP - Expert	BI - Intermediate KN - Novice KS - Expert NT - Expert CO - Expert TE - Novice UP - Expert OE - Intermediate	DE - Novice EH - Expert JE - Intermediate QG - Intermediate BT - Novice JX - Novice	IT - Novice QB - Novice NL - Expert SX - Expert NP - Expert JP - Expert
Criteria Slow, quick movements, linear route, little or no hot text, simple route	**Criteria** More mobile, slightly faster sections, some movement through features, small amount of hot text	**Criteria** Some linear progression, flatter lines, less frenetic, some hot text	**Criteria** Very active, some linear sections, at different levels, high hot text use	**Criteria** Linear route, some star movement, mostly linear progression	**Criteria** Linear progression, some hot text usage, faster than Group 1, more active	**Criteria** Linear sections with some more in-depth searches or parts of searches, different features used, some hot text

This connection between the tasks and the navigation patterns needs further exploration, as using twenty users, but with four different options in the second task, may be too few to fully explore the relationships between task types and navigational patterns that are supported but also encouraged. The in-depth interviews were necessary to determine the navigation patterns, but future observations could explore task and navigation patterns links with larger numbers of individuals.

15.6 Depth of Research by users

Returning to the research questions, the second study investigated whether or not individuals have preferences for certain navigational patterns and whether these are related to the user's approach to the software and to their use of working strategies. Users did develop links between topics even if none existed in the resource. This would have allowed connections to be made within the subject matter. However there was a great range in this and some users had very shallow depth in their working strategies. These users would look at very few links or further information and only explored the topic in a limited way. The use of the first Orientation strategy, could be determined as using a 'surface learning' strategy. At the other end of the spectrum using the two Composite strategies implied a deep searching element. Users who used a combination of these strategies, i.e. Orientation and Composite strategies, were relatively rare. The majority of users employed one of two main methods: 1) an Orientation strategy with some use of the Researching strategy, which only rarely created a deep approach, 2) a Researching followed by a Studying strategy (or more rarely, a Composite strategy), producing a deeper overall strategy. In order to develop the user's awareness of the techniques of searching and the available facilities within the multimedia package, some form of multimedia learning environment would be beneficial, especially to novice users. This allowed access to a range of resources and would produce information on the student's progress, how they used the material, their approach, links, and ways they could develop their learning. Investigating a user's development through the session and the re-use of patterns and strategies helps to provide an answer to the key research question of whether different navigation patterns can be learnt and taught. There was evidence that navigation patterns could be learnt, as several users reused patterns from the second task in the third task. This represented a definite change from the methods of navigation these users employed in the first task, especially when the users used the new navigation techniques exclusively.

15.7 Features and tools Used

There was initial interest in finding out what features were available. Usually several features were explored in the session, especially in the first browsing task and the open Task 3, but less so in Task 2. However a few users examined only a few of the available features in the whole session. Table 15.6 (overleaf) details each user and the features and tools they used. This has been arranged in order of Novice, Intermediate and Expert, although there were few differences in tool use between the three groups, and individual preferences were the most relevant criteria. The most commonly and heavily used feature was the Find or Pinpointer feature.

Table 15.6 List of the features and tools used by each user

FEATURES/ TOOLS	NP	EH	UP	KS	NL	CO	NT	SX	JP	OE	BI	JE	QG	TE	BT	JX	DE	HN	IT	QB	Total
Find/ Pinpointed	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20
Find Wizard	√				√								√			√	√				5
Media Features	√	√	√	√	√	√	√	√		√	√	√		√	√	√		√	√	√	16
Media Gallery			√		√	√	√	√		√	√				√	√		√	√	√	12
Interactivities			√		√		√		√	√					√	√					7
Guided Tour		√					√			√				√	√	√		√	√		8
Atlas	√			√	√		√				√				√			√	√	√	9
Timeline	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	19
Mindmaze	√					√	√							√	√					√	6
Collage	√	√	√	√	√			√	√		√	√	√	√	√	√	√	√			15
Options	√	√			√		√		√	√	√	√	√	√	√	√	√	√	√	√	16
Online	√			√		√		√	√			√	√		√			√		√	10
Back	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20
Dictionary	√				√		√	√	√	√	√	√		√					√		10
Hot Text	√	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√		√	√	18
Additional Info	√			√	√			√	√		√		√	√	√			√			10
Tools	√		√	√	√			√	√		√	√	√	√	√	√		√	√	√	15
Totals	14	8	9	10	14	8	12	11	10	10	12	10	9	12	15	12	7	12	11	6	

Average number of tools used – 10.6

15.8 Post-test interview analysis and results

The post observation interview consisted of a set question series with an interview format, allowing further expansion of the responses. This interview was a valuable source of information as most users completed this immediately after the multimedia session. They were willing to talk about what they did and why, and asked questions. Responses to the post observation interviews covered: general overview, awareness of structure, areas looked at, personal preferences, the user interface and the tasks, strategies used, knowledge or learning and navigation techniques. They were less factual than the observations and pretest questionnaires, and related closely to the actual experience of using multimedia, especially for first time users. This has meant that these interviews were more difficult to analyse. Features the users liked were: the Timeline, the overview, the basic layout, the standard format, pictures or graphics, animations, sounds and music, increasing text size option, the game, the topic contents and the article's richness. The Timeline was good for putting things in a broader historical context. Features that were disliked were: the sliding menus, changing disks, too much text scrolling, the Pinpointer and search, and the lack of hot links.

15.9 Post-test questionnaire information on tools used

There were several different tools and combinations of tools cited, but most users seem to have used the Find or Pinpointer for most of their searches. The tools used, and the specific combinations of these, by the Experts and Intermediates are shown in Table 15.7.

Table 15.7 Tools used by the Experts/Intermediates

Tools Used	Users with specific tools
Find or Pinpointer	OE, EH, UP, TE, CN, BI, JP
Hypertext, Pinpointer, Timeline	NP
Find, category, media reduction methods	JE
Overview, tools, structure, keep record of paths	JX
Timeline, specific searching via pointer, general subject, refine	SX
Find Wizard then Find	QG

15.10 Post-test interview comments

User comments on the post-test interviews have been used in the interpretation of the results. It was considered necessary to include at least some of the comments in this thesis. These comments have been categorised into areas and summarised in Appendix 4. These are as follows:

1. Comments on the tasks - Each of the Tasks have been dealt with separately. Some comments refer to all tasks, and these have been included in the most appropriate place.
2. Comments on knowledge, structure of the package and the strategies used.

15.11 Follow-up questionnaire

The follow up interviews had very variable responses and have been grouped into three categories:

1. Poor recall group, with little remembered, with a minimum amount or nothing from the Set Task 2, slightly more remembered from the free selection Task 3: QB, IT, DE, NL, EH, JX (4 Novices, 2 Experts).
2. Medium recall group, variable amounts remembered on Task Two - the Romans, but more on their own topics: JP, QG, UP, BI, JE (3 Intermediates, 2 Experts)
3. Good recall group, coverage variable, but much more successful than other groups, on both the Roman and on their own task good recall: KS, NP, TE, KN (2 Novices, 2 Experts)

The six Experts were evenly distributed across the groups suggesting (although this is a small sample) that the degree of skill and ability in accessing the multimedia software has little relation to the knowledge retention. The key point is that although the experts did not retain knowledge of the substantive content, they did retain and develop their IT skills through the packages. One of the determinants of good recall was in remembering the sequence and reasons for following a search. Several users recalled significant items in their search, and detailed their searches. A few users asked for key facts and were then able to recall their searches.

15.12 General points from the second study sessions

The quality of the learning attained during the tasks was difficult to assess, because of the small quantity of retained knowledge, and little comparative information on improvements in knowledge. It was decided that any assessment of learning that took place within the multimedia session would be difficult, and outside the thesis' scope. The issue of what was learnt in terms of content relates to their use of navigational patterns and working strategies and it was considered appropriate to assess recall. Users commented they would have recalled more for a specific purpose, or for their own research. Most users remembered the subject and content from the open task, relating their retention to interest and prior subject knowledge. Where the user had extensive subject knowledge e.g. for the set navigation route (Task 2), it was difficult for them to separate what they had covered in the session from prior knowledge. Other users were not interested in the subject (in Task 2) or started willingly, but reached a cut off point. Personal interests and prior knowledge were significant, and users employed these extensively.

The browsing task was used to check prior knowledge and the user interrogated the package for particular subjects. Users returned to prior knowledge, checking information and exploring, and they compensated for the lack of hot text links by developing their own, especially if the search finished abruptly. Use of links varied considerably, and several types of hot text user emerged, from infrequent hot text users, to users employing hot text if appropriate, to heavy users following every link and creating their own. Prior knowledge affected motivation, as, especially in Task 2, they continued only if they liked the topic. A distinguishing feature of the Experts was their speed of use. This was apparent both in using the package and having an awareness of when a search was not working, or had been exhausted, and in developing alternative strategies. An awareness of the need to do this, and the benefits of this behaviour are invaluable to the Novice user, especially when they are using a restricted or time limited resource. The tasks, the user's views of the tasks, and how they performed them have been described in detail. There were certain software features e.g. Pinpointer, which had extensive use and others e.g. the dictionary, had relatively little use. Most of the users relied quite heavily on text as the main means of using the software, and yet many of them disliked reading text on the screen. However there was a common use of pictures, maps, video and interactivities across the users, especially with their own research, which was common to both first and second studies. Children preferred graphic and specific multimedia features: videos, simulations, and interactive sections.

While the adult users preferred the specialised features e.g. interactivities or collages, they were critical of these and became aware of their limitations very quickly. Off task time was variable, but most users were off task at least once, although often remaining in the subject area, but not on the prescribed route. This occurred less on the Timeline route (Route A, Task Two), and mostly on Route B (Task Two), with high text content. Where the user was interested in the set route's subject matter they followed links, made detours and were involved. The less interested user left the topic completely or spent time searching for interesting material. There was less evidence that the user had more off task time if the route was more complex, although there is a relationship between the navigation route and the amount of off task time (especially on the high text content routes). The average total time taken by the users over the three tasks was approximately 65 minutes. The pretest questionnaire, final questions and post-test interview added to the time taken, but the total time did not exceed 100-110 minutes. General comments were that navigation was too linear or forced, and that navigation was difficult when not helped by a large text resource.

15.13 Verification of the navigation patterns

An informal meeting of two senior academic researchers (in the Institute of Educational Technology) at the Open University and myself was held to review the navigational patterns classification. The classification of navigation patterns was reviewed in detail at this meeting. The meeting was held in a large meeting room at the Open University where it was possible to layout the exact paths of each of the 20 participants. Each of the navigation routes followed by the 20 participants in each task (60 in all) was produced in graph format. These graphs had been placed in a sequence representing the different types of navigation patterns and clustered according to the type they were most representative of. Each of the two researchers reviewed the navigational pattern classification in detail and after some discussion and clarification on specific points and attributes, the classification was agreed as being an accurate and workable topology. Although these discussions were informal and the meeting was not formally recorded this was regarded as a significant part of the verification process for the classification. The verification process at the initial stage was recorded and placed in the thesis. An expert panel was convened at the end of the analysis period, to review the classification system proposed in the thesis and compare this to the classifications of the other researchers (now decided as being Horney and Parunak), i.e. to formally assess the navigation patterns. The expert panel has been briefly explained in 15.14 and the results of the expert's panel (together with the questionnaire format) are recorded in Appendix 5.

15.14 Verification of navigational patterns – Expert panel

In addition to the initial informal verification (15.13) a further verification assessment was done on Fenley's (this thesis') navigation patterns. An expert panel was asked to assess Fenley's navigation pattern classification in comparison with those from two other researchers (Horney and Parunak). A sample of their work was taken from the thesis, comprising an outline of their classification, a diagram, and an explanation of their navigation patterns. This background information on the three researcher's work (Horney, Parunak and Fenley), as given to the expert panel, is included in Appendix 5 followed by the questionnaire, the expert panel's responses to this, and then an analysis and discussion of these responses. An additional question was asked on the Horney and Parunak research as to whether or not it would be possible to develop a formal representation of their classification as had been done for Fenley's classification, (cf. formal representation, Section 15.16). The panel was informed that it was not necessary for the new navigational scheme to prove to be superior.

15.15 Results of the Expert panel

15.15.1 Comments on Comprehension/ Understanding

The expert panel was asked to consider each of the researchers patterns in sequence and so usually went through the sequence as Horney, Parunak and Fenley. Horney's patterns were regarded as being intuitive, straightforward, 'comparable to search categorisation elsewhere' and mostly scored Easy or Very Easy. Parunak's specialised terminology was found difficult to understand, were considered not as easy as Horney's but were reasonably easy to follow. Scoring two difficult and three easy, his classification caused more variation in the panel and scored the worst on the comprehension/ understanding question. Parunak's patterns were derived from a designer's perspective, were slightly more complex than Horney's but the panel found some patterns such as hypercube and hypertorus not very intuitive and 'representing some odd constraints'. Fenley's patterns had more clarity and more detail and exemplification. This classification was considered the easiest of the three, but also the more complex, partly because there were more patterns. The main advantage of the scheme was stated as having 'the description of level changes as well as node transitions'. One of the five experts classified Fenley's classification as difficult but the rest rated it as easy (3 experts) and one on the midpoint. The query on what is meant by a pattern would have been clearer if they had been given the whole thesis, as the patterns represent paths users have followed through multimedia. Hence the comment on whether they are 'what users do' is true, although the reason for doing the research was primarily to match the methods that users employ with the navigation patterns within multimedia. Matching these different ways to the design structures of future multimedia would promote the design and use of user-determined or user-friendly software.

15.15.2 Experts' on the ease of use of the classification

Horney's classification was classified with three experts on the mid point and one very easy and easy but the experts found it difficult to assess in theoretical terms and may have needed more direction in the type of package that the classifications could have been used for. However the panel members were all multimedia experts and would all have known a selection of multimedia packages on which to apply these classifications. The panel did state that it probably would not be that difficult to apply and that the descriptions were unnecessarily rigid giving an analysis of poor practice from a usability viewpoint, and that the chaotic category would be difficult to recognise. Parunak's was regarded as having pretty distinct categories so that ease of use should not be a problem. Parunak's ease of use brought up a comment that there is a trade-off between simplicity and rigidity and complexity and flexibility. The expert also stated that their choice would depend on a number of factors such as the nature of the task being carried out and the characteristics of the user. Finally they stated that these patterns would be difficult in reality and would need lots of user testing and prototyping. The comment that 'the lack of clarity and incomplete specification could make interpretation and categorisation difficult in particular circumstances', is very important and a significant although detrimental critique of Parunak's classification. Fenley's classification was 'probably the easiest in that it looks easy' although it did also engender the comment 'possibly a bit cumbersome', but it scored easy (2 experts) or the mid point (3 experts) in the scoring.

15.15.3 Experts' on the applicability of classifications

The comments on the applicability of the classifications had several favourable responses. Horney's was considered as applicable and that it could be used for website navigation. Another expert who mainly used the web commented that Horney's classification could be rather limited and rigid. A final comment on the applicability of Horney's classification was that it was not nearly as powerful as one would wish. Parunak's applicability was considered difficult for web pages as the terminology is different, and again problems were found with two of his patterns (hypercube and hypertorus). A comment from one expert that it depends on the context is interesting as the classification was meant to be applicable to a range of contexts, but the follow-on statement that the applicability and appropriateness of this scheme are potentially problematic is more worrying. Fenley's classification had more potential for describing website navigation due to some relevant examples, that it could easily be applied to web sites and also that the sheer complexity of the patterns would make it likely that the classification would fit the structure of the websites that they use. The scoring on this question was variable, Horney having three good fit scores with one mid point and one poor fit, Parunak scoring less with four mid point and one poor fit, but Fenley had all five experts scoring the good fit category.

15.15.4 Experts' on formalisation

Horney's classification in terms of producing a formal representation produced a range of comments. One comment was that the variation in each category seemed a bit vague so they are probably hard to formalise. Another comment was that it would not be hard to formalise, although the chaotic pattern would be hard, and a final comment on what was the purpose of this and was it to automate analysis? Parunak's classification was thought possible to formalise, but probably it would be more difficult than Horney's and finally that formalisation is potentially easy but would rely on the improvement of the poor and incomplete specification. Fenley's formalisation was regarded by one expert as not being very helpful, but that it could be useful shorthand for someone familiar with the scheme who is using it to classify navigation activities. Fenley's formalisation was generally regarded as being good, and that it would be nice to have program counts on these patterns in a web server's log file, and that as she had already done the formalisation it is definitely possible for her classification. The scoring for the formalisation question was again varied Horney getting two easy and three midpoint, Parunak getting five midpoints and Fenley getting three easy and two midpoint responses.

15.15.5 Discussion of the expert panel verification

Horney's patterns were considered reasonably straightforward by most panel members. Parunak's patterns proved more difficult to understand perhaps because of the specialised terminology used and his patterns produced comments on certain patterns (such as the hypertorus and hypercube) that they would be difficult to envisage in a multimedia context – 'lack of clarity and incomplete specification could make interpretation and categorisation difficult'. The expert's opinion on Fenley's formalisation seemed to be more variable on how possible or easy it would be to do a similar exercise for the other classifications and it is my contention still that it would be difficult to do this with the other classifications as neither of them are specific or detailed enough to do this, a view shared by at least one of the experts. Fenley's patterns were reasonably well received, and were described as having the most clarity and the easiest, although another expert described them as the most complex but qualified this by saying that there were more of them.

15.15.6 Conclusions from the expert panel review

Although the scoring was variable Fenley scored well on the Applicability and Formalisation categories and better than the other researchers on most categories. Horney was obviously reasonably easy to understand but had limited examples and his research was on a relatively small scale. The fact that Parunak's work was theoretical and that he did not try out his categories is significant, as examples of their use would have helped in their comprehension. The expert's panel has been positive about Fenley's classification and has produced few critical comments. They considered the classification to be workable, applicable to multimedia and to web navigation and comprehensive. The expert panel questionnaire has supported Fenley's classification and has helped to validate the sequence of patterns with an expert panel conversant with multimedia and web navigation reviewing and positively assessing this classification. The rationale for drawing together the panel and their assessment outcomes has been vindicated, as the panel supported this classification and having additional verification from other sources confirmed the range and usefulness of this thesis' classification.

In Table 15.8 (overleaf) the total items on the right column are weighted (using the scoring 1 for Very Difficult to 5 for Very Easy/Good Fit). An item in the 5 column would therefore score 5, while an item in 3 would score 3 and so on.

Table 15.8 Comparing results from the Expert panel

Very Difficult/Poor - Very Easy/Good Fit

Horney	**1**	**2**	**3**	**4**	**5**	**Total**
Comprehension/ Understanding	**0**	**0**	**1**	**2**	**2**	**21**
Ease of Use of classification	**0**	**0**	**3**	**1**	**1**	**18**
Applicability of classification	**0**	**1**	**1**	**3**	**0**	**17**
Formalisation	**0**	**0**	**3**	**2**	**0**	**17**
Total	**0**	**1**	**8**	**8**	**3**	**73**
Parunak						
Comprehension/ Understanding	**0**	**2**	**0**	**3**	**0**	**16**
Ease of Use of classification	**0**	**1**	**3**	**1**	**0**	**15**
Applicability of classification	**0**	**1**	**4**	**0**	**0**	**14**
Formalisation	**0**	**0**	**5**	**0**	**0**	**15**
Total	**0**	**4**	**12**	**4**	**0**	**60**
Fenley						
Comprehension/ Understanding	**0**	**1**	**1**	**3**	**0**	**17**
Ease of Use of classification	**0**	**0**	**3**	**2**	**0**	**17**
Applicability of classification	**0**	**0**	**0**	**5**	**0**	**20**
Formalisation	**0**	**0**	**2**	**3**	**0**	**18**
Total	**0**	**1**	**6**	**13**	**0**	**72**

Table 15.8 compares the three navigation pattern classifications from Horney, Parunak and Fenley with the combined results of the expert panel. Each aspect of the navigation was looked at in terms of its comprehension, ease of use, applicability and formalisation (see Appendix 5 for full results). Each of these factors was given a score from 0 to 5 (with 5 being the most successful/ easiest to use). The scores for each element are put into the table and the totals represent the combined scores. The overall classification from Horney and Fenley are close and considering Fenley's patterns are more detailed and comprehensive than those of Horney this demonstrates that they are still reasonably understandable and useful. It is interesting to note that Horney scores higher in the comprehension and ease of use categories and that Fenley's classification scores higher in the applicability and formalisation areas. The formalisation score is not surprising as the Fenley classification is the only one of the three to have included a formalisation. One of the experts commented 'notionally she has done it', but then did not score this question (giving a 5 score rather than the 3 allocated would have increased the total score to 74, one above Horney).

The important outcome of this is that even if the classification is detailed and extensive it can still be understandable. A workable classification also needs to be applicable to multimedia (and probably also to web structures) and it has to be able to be formalised in order for other researchers to implement it and use it in exactly the same way. As discussed in the literature review, although Horney and Parunak have both produced classifications there is not enough exact information on each of their navigation routes to make an exact classification and therefore it would not be possible, with the present information to create a formalisation for these classifications. In conclusion the expert panel has validated Fenley's classification, and it stands up well to the more established (but less tried and tested) classifications of Horney and Parunak.

15.16 Formal representation of the navigational patterns

A formal representation of the navigational patterns was developed after the navigation results were analysed. The formal representation is an exact definition of the parameters of each pattern. This makes the pattern more fixed in terms of allowing other researchers to follow the pattern exactly and to allow them to find examples of the pattern in practice but does not restrict its application. It was felt necessary to have a rigid interpretation of each pattern, as this would allow further comparisons of user's patterns in terms of exact patterns used.

The formal representation is included below. One aspect of the expert panel's work was to include an assessment of whether the classification of the other two researchers (Horney and Parunak) could be interpreted in a similar way and that a formal representation could be made. In my opinion (and this is verified by some of the expert panel, the rest of the panel did not feel sufficiently expert in formalisation methods to determine this) navigational patterns of these two researchers are not detailed enough to allow this to be done. Further information on the panel's views, questionnaires and their individual responses is included in Appendix 5.

FORMAL REPRESENTATION OF THE NAVIGATIONAL PATTERNS

Definitions

Navigational patterns consist of a series of nodes, node(1), node(2) ... node(n). Nodes consist of individual screens, possibly supplemented by video, collages or other activities. Each node is located at a level in an ordered structure. The level of node(j) is denoted by level(j). The level immediately above node(j) is level(j) + 1. The level immediately below node(j) is level(j) – 1.

Patterns

A pattern is *linear* if there exist three successive nodes, node(1), node(2) and node(3), such that level(1) = level(2) = level(3).

A pattern is *linear extra* if there exist five successive nodes, node(1), node(2), node(3), node(4) and node(5) such that

(a) level(1) = level(2) = level(4) = level(5) and

(b) level(3) = level(1) ± 1.

A pattern is *star* if there exist five successive nodes, node(1), node(2), node(3), node(4) and node(5) such that

(a) level(1) = level(3) = level(5) and

(b) level(2) = level(1) ± 1 and

(c) level(4) = level(1) ± 1.

[Note that level(2) need not be the same as level(4).]

A pattern is *star extra* if there exist four successive nodes, node(1), node(2), node(3) and node(4), such that

either

(a) level(2) = level(4) = level(1) + 1 and

(b) level(3) = level(2) + 1

or

(a) level(2) = level(4) = level(1) – 1 and

level(3) = level(2) – 1.

FORMAL REPRESENTATION OF THE NAVIGATIONAL PATTERNS – cont.

A pattern is circular if there exists a series of nodes, node(1), node(2) ... node(n), such that

(a) level(1) = level(2) = ... = level(n) and

(b) node(n + 1) ≡ node(1).

A pattern of nodes, node(1), node(2) ... node(j), on a circle, node(1), node(2) ... node(n) is *circular* if $j > n/2$. (If $j \leq n/2$, the pattern is linear.)

A pattern of nodes is *hierarchical* if there exist four successive nodes, node(1), node(2), node(3) and node(4), such that

either

(a) level(3) = level(2) + 1 = level(1) + 2 and

(b) level(4) ≠ level(3) – 1

or

(a) level(3) = level(2) – 1 = level(1) – 2 and

(b) level(4) ≠ level(3) + 1.

A pattern is *complex* if it fits none of the above categories.

15.17 Topologies of the software packages

The structure of the multimedia packages used in the research have been analysed and produced as two-dimensional charts called topologies. Each topology recognises the layers in each package and lists the main topics or themes and the subtopics. For Study 1 three packages (out of the five used) were analysed: Eyewitness History, Medieval Realms, and The Way Things Work. It was not thought necessary to produce topologies for all the packages used in Study 1 (which also included Peanuts and Grolier's Encyclopaedia) although it would have been possible to do this. However the Peanuts package had a very simple linear structure and Grolier's encyclopaedia had a typical hierarchical structure for an encyclopaedia and was similar to Encarta, although less well structured and developed. In Study 2 Encarta was analysed to provide the structure of the topology. These topologies are in Appendix 4.

15.18 Linking the topologies to the navigational patterns

Once the topologies were completed an overlay was constructed for two of the packages – Eyewitness History from Study 1 and Encarta from Study 2. Each navigation pattern is shown with an indication of how this might be recognised within the package. The topologies and the respective overlays are presented at the end of this part at the end of Chapter 17 (and are labelled Fig. 17.1 and 17.2).

15.19 Examples of the recognition of navigational patterns in navigation routes

Examples of the usage of the multimedia packages in Study 1, has been given in the thesis text when describing the navigation patterns. This information for the First Study is located in Chapter 9 (Chapter 9.7).

In Study 2 the participants used the Encarta Encyclopaedia. In the linear pattern, progress would be made by viewing consecutive screens on the same level such as in Life Sciences moving from Algae and Fungi to Plants and Invertebrate Animals. For the Star pattern a change in level is necessary so the user would need to drop from Level 2 to Level 3 and return, hence for the History category the user would need to go from the History menu to United States History back to History and then to European History. Examples of a sample of navigation patterns in use in the user's navigational patterns are given below. The formal representation of the patterns (Section 15.16 above) defines the possible movement through the resource in precise terms. Some examples of the use of patterns have been included here from user outlines:

Linear - There are many examples of the linear route. One if these is User 12 (QG) used consecutive points along the same route while investigating Gardening – Special gardens, Japanese gardens, Flowers, Begonia etc

Star - The Star pattern is recognised with User 5 (JX) in the third task where environmental pollution is the main theme. The route covered environment –recycling – water pollution – hazardous waste – environment – pollution control, where the user continually descends down one level and returns back to the original level.

Hierarchical - The hierarchical pattern is demonstrated by User 10 (KS) with two examples. The first of these involves exploring the heavens and moving through the text to Comets and the second search on Bio Diversity was investigated using a hierarchical search – Bio Diversity, going into the Web of Life, Diversity Collage and continuing on with increasing depth along the same search.
Complex - The complex routes of two users – User 15 (SX) and User 8 (UP), both show rapid movement and frequent changes in both direction and topic. Parts of their routes may be attributable to other component navigation patterns but these are short sections of the route and are insufficient to formally identify the specific pattern (following the formal representation). Their route's complexities and the speed of delivery are discussed in the navigation patterns chapter.

Table 15.9 Comparisons of stability across Task 1 and Task 3

	Low (L)	L/M	M	M/H	H
Novices	0	0	1	1	5
Intermediate	1	0	0	2	1
Experts	1	2	2	1	3
Totals	2	2	3	5	9

The comparison between Task 1 and Task 3 in terms of topics, patterns, tools and stability has been given low (L), medium (M) and high (H) ratings. This means that a high rating has high levels of similarity over the two tasks, a medium rating has some degree of similarity but also some differences, and low has limited or no similarity. If the rating is split L/M or M/H there is a mixture in the degree of comparability. Table 15.9 above gives an analysis of the numbers of each of the participant group who have low, medium and high stability across Task 1 and Task 3.

There are nine users (out of 20) who have high stability across Tasks 1 and 3, and 5 more users with medium to high stability, 3 with medium stability, 2 with L/M and only 2 with low stability. Analysing by group the novices have five with high, 1 M/H and 1 M, and none with low stability, intermediates 1 High, 2 M/H and 1 Low and experts 3 with High, 1 Medium and 2 M/H and 1 low, cf. Table 15.10 overleaf).

In Table 15.10 overleaf Task 1 and Task 3 for each user are described in detail, stating each feature or tool used and the subject viewed. In the third column labelled Task 1/3 the navigation patterns that are common to both tasks are listed (although these may not be the only patterns which are used in the tasks). In the column labelled comparison the tools and features used for each of the two tasks (1 and 3) are compared. In the final column labelled stability the tasks are compared and a rating for stability across the tasks is given.

Table 15.10 COMPARISON BETWEEN TASK 1 AND TASK 3 (next four pages)

	TASK 1	TASK 3	Tasks 1/ 3	Comparison	Stability
1 NP EXP Task 2A	Features, Options, Media Features, Online Features, Pinpointer, Cities Dictionary, Word Search, Category, Media, Kubla Khan, Marco Polo, Timeline, Mongolia, Maps, Games, Children Games, Folklore, Collage, Myths, Legends, Fairy Tales	Symbolist painters, Pinpointer, Blake, Poetry, Lamb, 17/18C Samuel Palmer, Children's Lit., Media Features, Gallery, Keats, Symbolist, Moreau, Hodler, Mythology, Folklore, Collage, Fauvism	Linear Hierarch.	Pinpointer – easy to use, search methods, Some use of same topics, frequent use tools, little use of Timeline from task 2	1st task reused in 3rd task methods not Timeline as 2nd Medium stability
2 TE NOV Task 2A	Media Gallery, Guided Tours, Ecosystems, Great Wall, Cave dwellers, Jericho West Bank, Rift Valley, Timeline, Dead Sea, Teeth, Palestine, Mammoth, Mindmaze, Pinpointer, Dictionary, Collages, Exobiology, Heavens, Copernican System, Stars	Timeline, Great wall of China, Collage, China – Intro, Land/ Resources/ Regions, New Asia, Shanghai, Timeline, China, Shihangdi	Linear	Similarity of subject, linear routes (Timeline) and routes used	High level of stability, subject found in Task 1, used similar tools & from Task 2 - 3
3BT NOV Task 2B	Media Features, Media Gallery, Interactivities, Famous Paintings, Dali, Nutrition, Collages, Online Features, Tools Guided tours, Places to visit, Mindmaze, Timeline Pinpointer, Sports, Skiing	Skiing, Pinpointer /Word Search, History of Skiing, Europe, History, Snowboarding, French Alps, Swiss Alps, Cross Country Skiing, Nordic skiing, History of skiing	Linear Hierarch.	Very compatible, same subject& tools used, kept to topic	High level of stability, same topic, similar tools Task 2, heavy text – not read
4OE INT Task 2B	Silversmithing, Media gallery, Teapots, guided tours, Snapdragon, Interactivities, Language, Famous painting Georges Seurat, Game	Write a poem, Post Modernism, mod Roman Catholicism, Symbolism, Learning, Confucius Montessori, mind, Consciousness States Theory, perspective perception, philosophy, psychology, Wittgenstein	Linear	Similar tools but totally different subjects, different approach, different routes	Low stability level few tools re-used, range high

	TASK 1	TASK 3	Tasks 1/ 3	Comparison	Stability
5JX NOV Task 2C	Features list, Media Gallery, Pinpointer Dickens, Interactivities, Famous Paintings, Gallery, Millet, Natural Wonders, Serengeti, Guided Tours, Nahib, Role Models, Visionary Thinkers, Darwin, Muhammad, Collage Online Features, New York Bird Flower Statue of Liberty	Environment, recycling, hazardous wastes, environmental protection agency, water pollution, thermal inversion, air pollution, landfill, legislation, resource conservation, Notemark, reclamation, Pinpointer, Detailed record	Linear Hierarch.	Different subject areas, some reuse of tools, interactivities, Pinpointer/ Guided Tours	Medium/ High Stability, Diff subjects, Similar tools patterns
6BI INT Task 2C	Features, Media Features, Atlas, Indian Ocean, Seychelles, Options, Views, Seafloor, Sea Creatures, Loch Ness, Imaginary number, Monsters, Creatures, Mythology, Collage, Folk Lore, Sindbad	Mythology, Folklore collage, Birth/ Rebirth, Millennium, Foundation myths, language, animism, Benin, ritual healing, Malawi, Pinpointer, Healing, Ritual, Music, Indian Music, Classical Dev, India, Sitar, Classical Instruments	Linear Hierarch.	High comparison between 1 and 3 tasks, similar use of tools & paths	High – common use of topics, and tools
7EH EXP Task 2D	Guided Tours, Famous islands, Timeline, Mali, Mexico, Aztec, Japan, Asia Collage, Medicine, Guided Tours – Marine Life, Dolphins, Bat, Flight, Amazon – Swallows & Amazons, Roosevelt, Churchill	Computers, Uses, CPU, Bus & mechanical mouse, optical scanner, microphone, memory, hard disk, integrated circuit, microprocessor, EPROM, Unix OS/2, Devs, Turing, Common 8bit, 16bit, byte, Kilobyte	Linear Hierarch.	Little similarity over topics, some similar use of tools	Low/Med stability, use of same tools little subject similarity
8UP EXP Task 2D	Pinpointer, Aardvark, Shrodinger, Durne, Heidelberg, Cat, Mysticism, Distance Ed., Thorndike, Ed. Psycho, Pavlov, Skinner, Piaget, Behaviour, Ed. Technology, Bellamy, Major Philip Rendolph, Copland, Abraham Lincoln, Acadia, Animations Bernoyli, Oth. Media, Lizard, Media Gallery Interactivity, Notre Dame	Time/Time travellers, Solar, Standard Ephemeis Time, Relativity, Physics, Confirmation & Modification, calendars, clocks, watches, chronometers atomic clock, mechanical clock, Seth Thomas, Ancient Calendars, Julian Gregorian, Jewish, Biological clocks Stonehenge, Calendrical theory	Linear Hierarch.	Some use of same tools, different topics	Low stability, some tools reuse, diff. patterns & subjects, little tool re-use

	TASK 1	TASK 3	Tasks 1/3	Comparison	Stability
9JE INT Task 2B	Features, Collages, communications technology, Place, NZ, Tasman national Park, Find category, Art, Lang & Lit, National & Regional Art, Pinpointer, carved native figures, Dutch watercolours, animations, Earthquake, video, Kobe, Shockwaves, Earthquakes – kinds /locations, /faults, /effects, finger-prints, predictions, Related Features - Tsunami	New Zealand, list, James Bolger, History, Timeline, parliamentary government, manufacturing, Maori, Music of New Zealand	Linear Circular	Some tool re-use, few topics with similarities. Likes sound so followed that, used Timeline, Pinpointer, find	Medium stability, some re-use
10KS EXP Task 2B	Features, Collage, coral reef, Exploring the Heavens, Hailey's comet, classifying comets, look for Hale Bopp, Hale observatory, Collage, Bio-Diversity, term, definitions, Web of life, vegetarian finch	Canals, locks as necessary evils, Grand canal of China, Ship Canal, Canalisation of the Arkansas River, Major Ship Canals of the World, map – Graphic, Tombigbee	Linear Extra	Some tools use but different subjects and routes	Low for subject, similar tools & routes, L/M
11NL EXP Task 2C	Children games, marbles, Media Features, Media Gallery, Life Sciences/ Social Science, Education, Children & MM, Gallery, Pinpointer, Atlas, Ukraine, Article, Flag, Anthem, Waterways in Ukraine, Christian mural, Electronic Plant, Timeline, 2500-1400-800BC Buddhism	Greek mythology, Features, tools, Notemark, 12 chief gods, Dionysus, Temple of Apollo, Mount Olympus, Home of Gods, Pegasus, Link to Perseus, Link to Dictionary, Collages, through Collage, Daedelus & Icarus, Labyrinth, Dictionary, Oedipus, Mythology, Media Type	Linear Hierarch.	Found mythology during Task 2, Close link to area, Similar patterns / tools used	High stability, links to all 3 topics, routes and tools used
12QG INT Task2C	Pterodactyl, options, Main Outline, Pterosaur, Big Bend National Park, SW Texas, California, Fact Box, Merced River, Yosemite National Park, San Andreas Fault California, Physical Geography, Map of California, Mount Whitney, Natural Regions, Sacramento	Gardening –Wizard (Task 2), Limit 1900-99, No articles, Find Wizard, Pinpointer, Flowers, Sport, hobbies, list of sports/hobbies, Gardening, special gardens, Japanese Gardens, Related Articles, Begonia, Forsythia etc, Botanical Garden, Reverse back	Linear Hierarch. Star	Few links across subjects/topics but stability in choice of tools and patterns	Medium stability

	TASK 1	TASK 3	Tasks1/3	Comparison	Stability
13CO EXP Task2D	Features, List of Features. Media Gallery, Media Pinpointer, Thomas Hardy, Nova Scotia, Coastline 360° Views, Mind Maze, Game	Shelley, quote, Frost, Quote, Start Word Search, Quote, Poem name Stepping by words, Robert Frost, Pinpointer, 49 articles - Coleridge, link to Frost, Pinpointer, Pulitzer prize winner, link across – Prize winners, poetry prize winners	Linear Hierarch.	Few links subjects/topics, but stability in choice of tools and routes	Medium stability
14NT EXP Task2C	Media Features/ Gallery, Parliament buildings, Ottawa, Oslo, Australia, Interactivities, Understanding Orbits, Paintings, Famous paintings -Modern Era, Icons, Still Life, Nutrition, Choose foods, Spaghetti, Media Features, Guided Tours, Sciences, Pseudoscience, Forces of Nature, Hurricane, Tsunami, Spiritual Tours, Jerusalem, Sinai, Mountain, Peninsula, MindMaze	Holy Land – historical Evidence, Noah, Noah's Ark, Mount Ararat, WP, Jericho, West Bank, Joshua, Exodus, Creationism, Miracle, Bethlehem, America, Roman Empire, Constantine the Great (Built Ch. of the Nativity) Jesus Christ, Flood, Timeline, Neolithic monuments, Avebury, Egyptian Pyramids - Timeline	Linear Hierarch. Star	Close similarity in subject areas, some reuse of tools and routes	High stability
15SX EXP Task2A	Pinpointer, Media Type, Animations, Earthquake, Alaskan earthquake, Fingerprint, Blake, William, Artist, The Lamb, A priori, Other works Francis Bacon, Shaba, Africa, More Info, Media Features, Interactivities, exploring fractals, magnify, Infinite complexity, in fractals – tree generator, Draw trees, Instructions	Socrates, Notemark, Environment/ Poll, Rome History, Interactivities, Animations, Video, Sounds, Basilisk lizard, water running, MindMaze, Pinpointer, Nelson, Notemark Lord Nelson, Service, Trafalgar, Clipboard, Nelson picture, Hood, Lady Hamilton, Australia, Trafalgar, Bonaparte – txt, Elba	Linear Hierarch.	Very similar text, Links from task 2 to 3, similar tools and patterns	M/H stability
16JP EXP Task2D	Pinpointer, multitasking, operating systems, Collage, communications, sound, Printing & Revolutions, Internet – how work, domain names, Internet protocols, Timeline, Bohr, Aage Niels, Kepler, & Laws, Orbital, orbit, Interactivity, Ptolemaic system elliptic	Kepler, Johannes- German Astronomer, Interactivity, Kepler's Laws, Understanding Orbits, The Principia, Heavens Collage, Tycho Brahe-Astrolabe, Calculus, Geometry by divisions, Development of Calculus	Linear Hierarch.	Same areas, subject areas covered, same routes, tools	High stability

	TASK 1	TASK 3	Task 1/3	Comparison	Stability
17OE **NOV** **Task2C**	Ice core, Antartica, Scientific research, Timeline, map, Climate, Explorers collage, Auguste Picard, Deep Sea Exploration	Jewellery, Diamond formation, Wt, Quality, Faberge Egg, Platinum, Ancient Gowns, Gemstones, Gem, & cuts, Turquoise, Optical Properties, Identification, Timeline, Middle Eastern /Frankish Jewellery, Art Nouveau, Mackintosh, Tiffany, Louis, Hot text, Dali, Persistance of Memory, Asian Jewellery, Tower of London, Odessa, Ukraine, Scythian Jewellery	Linear Hierarch.	Different topics, some use of same routes and tools	Medium stability
18KN **NOV** **Task2D**	Media Features, Atlas, Guided Tours, History, Politics, World Culture, Different dances, Ethnomusicology Ethnology, Guided Tours, World culture, Furniture, Time limit Knoll chair, Roman Furniture, Recons Roman Church, Eames Chair, Arts& Entertainment, World Beats, Trad drumming, S. India, Classical Instruments, Indian/Trad. Music Pakistan, Folk, popmus	Galicia, Media Gallery Spain, Fact Box, Population, Media Features, World Beats, Guided Tour, Indian Music, Arts & Entertainments, Pinpointer, Music, Non Western, Notemark, Arab Music, Migrations Collage, Classical Music, Azerbigan, Afghanistan, Morocco Arab, Folk music, Rhythm, Melody, Sufi S.India, Classical Instruments, Trad. Music Pakistan, Folk, Pop	Linear Hierarch.	Galicia link Task 2, links on music, explored in Task 3, re-use of Tools and Routes	High stability
19IT **NOV** **Task2A**	Media Features Atlas, Guided Tours, Tour Category, What's new 95/96, Monica Seles, New Tour, Places to Visit, Deserts, World Desert regions, Guided Trs, Places to Visit Napoleon, Famous Islands, Ellis Is Cookery, Herbs/Spices, Famous Streets, Appian, Arts/ Entertain, Trad drum- S. India, Classical Sarangi, Sitar, Class Dance	Africa/India, Atlas places, Indira Ghandi, Airport, Bombay, Architecture, Gujarat, Rajasthan, Folk music, Punjab state, Media Features, Atlas, India, Sound sights of Bombay, Pinpointer, India, Himalayas, Atlas, Japan, Tokyo, Business district, Media on Japan, Nerve gas attack, Rakanji Temple, Majin Shrine, Guided Tours, Plate Tectonics, Ocean & Oceanography, Pacific Ocean, Atlantic Ocean	Linear Linear extra	Link from Task 1 to Task 2, Link from Task 2 to Task 3	High stability, Topics/ Tools & routes
20QB **NOV** **Task2B**	AA Milne, Winnie the Pooh, Aardvark, Pinpointer, Online Features, Media Features, Atlas – Spain Alicante, Mediterranean Sea, Mindmaze	Kenya- Egypt Anthem, General Info, AvTemp, Land, Climate, Economy, Lake Victoria, Superior, Pyramids, Step, Timeline, Papyrus, Khufi, Gt Pyramid, Drawing, Cats, Egyptian Numbers, Australia, Kangaroo, Koala, Aborigines, Sydney Opera, Aboriginal Music & Treatment, James Cook, Australian Dev., New Zealand, Mount Taraki, James Bolger, Chatham Isles, Animals, Kiwi, Spider	Linear	Some similarity across topics – M/H, Same tools & routes	High stability

Table 15.11 Stability ratings across the User groups

User	Level	Task 2 Route	Topics	Patterns	Tools	Stability
1 NP	Exp	A	M	M	M	M
2 TE	Nov	A	H	M/H	H	H
3 BT	Nov	B	H	H	M/H	H
4 OE	Int	B	L	L	L/M	L
5 JX	Nov	C	L	M/H	H	M/H
6 BI	Int	C	H	M/H	H	H
7 EH	Exp	D	L	M	M	L/M
8 UP	Exp	D	L	L	M	L
9 JE	Int	B	L	M	M	M
10 KS	Exp	B	L	M	L/M	L/M
11 NL	Exp	A	M	M/H	H	M/H
12 QG	Int	C	M	M	H	M/H
13 CO	Exp	D	L	M	H	M
14 NT	Exp	C	H	M	H	H
15 SX	Exp	A	H	M	H	H
16 JP	Exp	D	H	H	H	H
17 DE	Nov	C	L	M	M	M
18 KN	Nov	D	H	H	H	H
19 IT	Nov	A	H	H	H	H
20 QB	Nov	B	M/H	H	H	H

Table 15.11 shows the stability ratings across the User Groups, looking at the three user groups and the route they were given through Task 2, and the assessment of the topics, patterns and tools across the tasks. From these ratings a stability rating was developed shown in the table above. The novices as a group have a higher stability across the two tasks; the intermediates also have high stability (with only one low rating). The experts are more varied with low to medium rating, although 3 have high ratings. It may be expected that the experts would have less need for stability and would use different methods for each task, which would increase their likelihood of having different levels of stability across the tasks. The range across the different routes is also mixed. There is generally good stability across Tasks 1 and 3.

15.20 Conclusions

The chapter on the second study has reported on how the empirical work was conducted and the results. This navigation patterns chapter has detailed an in-depth analysis of the software itself, features and tools used, the benefits and problems of use, user's comments, discussion of preferred working strategies, and the user's views of their navigational patterns. In terms of navigation definite patterns were being used, with users having a set of preferred patterns or always being complex pattern users. Certain tasks appeared to encourage certain patterns of navigation, for instance the browsing task (e.g. Task 1) tended to encourage linear patterns, while a search task (Task 2) was more likely to be hierarchical. Task 3, the open task, encouraged a hierarchical pattern, as it usually required the user to search down subject areas rather than across them. The wide range of subjects available allowed each user to select a topic of personal interest to them and because of this Task 3 may have had increased motivation, relative to the other tasks. Different people had varying tolerances to following the set route. Evidence from the research indicated that purely linear routes were often disliked and that these were frequently considered boring. However the Novices liked, and in relatively few cases, needed, a linear route.

A significant feature of the second study has been the division into the Expert, Intermediate, and Novice categories. The research indicated that Novice and Expert users need different levels of introduction to the package. These included ways of using the package, methods of using IT; ways of facilitating previously used methods to a new task, and encouraging their own ability to adapt their skills and abilities. A further significant result of analysing the skills, methods and techniques used by the Experts, was the potential for the Expert's performance in using multimedia to be adapted for training the Novices. Although there were differences in both their abilities and receptiveness for these ideas and techniques, there would be benefits from developing these expert skills. There was concern from the Experts over the need for a gradual progression of the Novices skills and abilities in using multimedia. Time and comprehension are required, from the time the Novices commence using multimedia software, until they are able to understand and replicate the full potential of the Expert's performance.

The expert, intermediate and novice divisions were relevant for certain analyses; however there are others, such as the analysis of the individual routes for each task, which do not follow these divisions closely. This supports the concept of the continuum of development for multimedia users and allows each individual to be placed on this continuum. The broad tripartite divisions are workable for the individuals who have attained a specific level of expertise but work less well with those individuals who are in the process of moving from one level to the next and hence exhibit some features of each group. The classification of patterns found in the original first study was used. The refocusing of the second study to adults enabled the full range of patterns to be tested and the patterns employed by the adults were all recognisable within the classification structure developed after the first study. It was therefore considered that this classification was comprehensive.

16

16.1 Introduction

This chapter on working strategies briefly summarises the strategies found from the children in the first study, using the background of the working strategies recognised by several researchers detailed in the literature review. The chapter then details the strategies the adults were using in the second study. The distinction between navigation patterns and working strategies is briefly explained here using navigation patterns as the physical (geographical) method for navigating. The working strategies are more difficult to assimilate as they represent the thought/mental processes that the user employs to work through the package. These have been captured by the user's comments during the session recorded with their movements, and their assessment in the subsequent interviews. Although tentative working strategies were observed during the children's sessions, the working strategies were not explored until the second study. Because of this and the smaller number of users the results were encouraging but more empirical work is needed to understand working strategies exactly and how they connect to navigation patterns.

16.2 Summary of working strategies from the first study

The five working strategies that were distinguished from a review of the literature and from an assessment of the working strategies found after the first study are as follows:

1. Orientation
2. Researching
3. Studying
4. Composite - Random and
5. Composite - Ordered

The analysis after the multimedia sessions of the first study revealed a limited use of working strategies and these were put into two main categories - broadly a basic type and a more complex type. The Orientation and Researching types, and the Studying and Composite strategies were grouped together. The contention that all the Orientation users were simplistic users and Composite users were more experienced but not expert users was put forward. The Orientation users only or largely used this strategy, but it was proposed that the Researching users were using the basic Orientation strategy and the Researching strategy. This would imply a more detailed and developed knowledge or understanding of how they were working through the respective software. This was supported by the fact that use of the Researching strategy increased with the age of the children. After further analysis it was possible to define these strategies further and this classification was used in the second study. This use of a broad definition for the first study, makes it difficult to compare the first and second study results (see Fig 16.1). However as the children used fairly straightforward and not complex navigation patterns, it was significant that their choice of working strategies was similarly restricted. This supported the decision to use adults in the second study to expand the use and testing of the full range of patterns and strategies.

16.3 Comparative research on working strategies

Having dealt with the navigation patterns in the previous chapter, the research on working strategies by Horney, Parunak and Canter, Rivers and Storrs will now be examined. These researchers found evidence of both dimensions i.e. navigation patterns and working strategies, in terms of the paths followed, and the way users preferred to work. Their research has already been discussed in relation to the navigational patterns and in the literature review. The work of Weinstein and Mayer (1986), Trumbull, Gay and Mazur (1992), Kolb (1984), and Horney and Anderson-Inman (1994), was relevant here. It is significant for this research that other researchers were differentiating and classifying between navigational patterns and types of working strategies. Weinstein and Mayer (1986) produced eight categories of strategies. However the criteria that Weinstein and Mayer employed, were different from those that were used in this thesis, and so their results were less applicable and less comparable to the results of this research. Weinstein and Mayer also cited Cook and Mayer's work, (1983) which identified four main components of the encoding or learning process as selection, acquisition, construction and integration. These were all relevant components, and they proposed a simplistic and linear system.

Later research has moved away from an initial linear position to one where each user can adopt several different approaches. These different approaches are valuable for comparing individuals, and for assessing each user against another. This method could be used to classify individual's preferences, i.e., the way they prefer to work. In allowing user's to select the working strategies that they prefer to use, the empirical work in this thesis demonstrated that users have distinct preferences for working strategies. This difficulty over the user's selection of multiple categories was a problem in Trumbull, Gay and Mazur's work (1992) with their groups (cf. 2.12). This problem related to difficulties in distinguishing between the groups, and whichever method was used to separate users, created problems. When assessing their students' work, e.g. which tools they used (or how they preferred to use the package), it was difficult to assess their results fairly. Although they separated the students by using standard deviations from the norm, some usage figures were higher than others, which implied the students were using very different amounts of specific tools. Horney and Anderson-Inman's (1994) research investigated similar strategies in hypermedia, which they termed hypertext-reading patterns. They found the following patterns: skimming, checking, reading, responding, studying, and reviewing. Four of their patterns were similar to this thesis's working strategies (cf.10.2) and this makes their research particularly relevant to this thesis. Firstly the skimming pattern, which relates well to my rapid Orientation strategy. Secondly their reading pattern was similar to my Researching strategy. Thirdly their studying pattern, which links text and resources, represented a similar strategy to my Studying strategy. Their reviewing pattern implied the need for repeating and rechecking completed work and related to my Composite strategy. They found that students adopted different patterns at different times, and had preferred ways of using the resources, which are both supported in my empirical work. Horney et al.'s research found that changing the software design affected student's interaction, e.g. improving the comprehension exercises meant students used them. A significant aspect of Horney et al.'s research, and one that was particularly relevant to this research was that they recognised two distinct dimensions in the way students used the software. These two dimensions were firstly, to interact with the hypermedia material (called the reading pattern) and secondly to integrate the use of the resources with the text (called the studying pattern). These compared well to the navigation patterns and working strategies distinction from my empirical work, and supported the need to have these two distinct elements for each user. Horney and Anderson-Inman used the reading pattern to analyse how the students used the resource, which was similar to the way navigational patterns have been used in this research. Horney et al. used the studying pattern to determine how the students integrated the resources with the text, or rather how they approached studying within the software. Their studying pattern compares with the perceived need in my research to classify the working strategies.

This awareness of differences in how the user navigates and processes the information was also recognised by Suchman (1987), Parunak (1989) and Canter, Rivers and Storrs (1985). Hence although other researchers separated these two activities, Horney and Parunak did some work on them but only broadly defined them, and only Horney completed a limited amount of empirical work. Although the selection of each individual's navigation patterns does appear to be linked with their selection of working strategies these two aspects are not always the same. A third dimension, search methods has also been recognised from the data and these search methods have been incorporated into the working strategies classification as they are closely aligned. It is possible to elucidate each individual's preferences in each of these areas. However further work is needed to understand the interrelationship of these aspects. The next stage would be to see if there are common patterns of navigation which link to the working strategies/ search methods. This was not the original intention of this thesis, which was to investigate if individuals had preferred navigation patterns. The relationships would need many more participants and would not have been feasible to add to this thesis due to time constraints. The empirical results support the third hypothesis that navigation patterns can encourage in-depth searching and potentially deeper working. Reed and Oughton (1997) found that students with different learning styles and differing degrees of computing experience have been shown to differ in their preferences for linear and non-linear pathways in a hypermedia program. Research by Hodgson (1984) found that where teaching was effective and enthusiastic, and where the student's freedom over topics and modes of learning or working were encouraged, these facilities encouraged a deeper learning approach. In the empirical work it was evident that each user had preferred navigation patterns and working strategies.

16.4 Evidence for working strategies use

The working strategies were variably employed by users in the empirical work with some users employing a limited one or two strategies, while others used several. In the first study there was a preference for one type of searching, although a few exceptions tried different strategies.

Table 16.1 Working strategies used in first and second studies

Working Strategies	First Study Children pairs			Second study Adults		
	Younger	Middle	Older	Novices/	Inter/	Experts
Orientation	4	9	8	1	1	3
Researching	Grouped	+ Orientation	- First study	7	3	6
Studying	1	5	4	2	1	6
Composite Random	Grouped	+ Studying	- First study	0	0	1
Composite Ordered				0	0	4

Table 16.1 outlines working strategies and their use by first study and second study participants. It is valuable to note how these patterns and strategies were used in conjunction with each other. The working strategies are now described with how they were used in the empirical work. The experts were prepared to leave the resource to find external sources as well as creating their own links within the package. This was exemplified by comments on the poor quality of the links, as some links were not implemented, despite there being suitable material in the resource, and enthused some experts into creating their own links. Some of the novice and intermediate users were prepared to follow up hot text links and exit out of the area they were investigating, but some users were unable or unwilling to do this, fearing an inability to return. Users circumvented this problem by fully investigating the area, before returning to links, when it would not matter if they did not return. This method affected their normal navigation methods, as they would usually follow up the links immediately. Most users had a set pattern of using one linear and one hierarchical strategy, the latter for more in depth searching. The quantities of usages were variable, especially in the first study, with users spending more time with one strategy than another, although there was a greater range with the adults. The adults commonly used both the Researching and the Studying strategies. Table 16.2 (overleaf) shows the working strategies in Study 2, while Table 17.1 (in Chapter 17) lists the navigation patterns and working strategies of each participant.

16.5 The assessment of the working strategies

The working strategies for the children's sessions had been assessed from their comments during the session, and more detailed questioning in the interviews. Their queries on these questions and the lack of complex strategies indicated that the younger group were following very basic strategies and the older children had begun to be aware of the different strategies and had started using them but were not very sophisticated or skilled in their use. It is possible that these skills would develop but they were not in evidence at this stage. For the second study it was expected that the adults would be more aware and in control of the strategies and that the degree of user control would be an important factor in their choice of working strategies, and a similar method of collecting and collating the strategies was used for the adult session.

Table 16.2 Working Strategies in the second study

Working Strategies	NP	EH	UP	KS	NL	CO	NT	SX	JP	OE	BI	JE	QG	TE	BT	JX	DE	KN	IT	QB
Orientation Delimiting	√	√		√		√	√	√	√	√	√	√	√			√	√	√	√	√
Researching	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
Studying	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√			√	√
Composite - Random	√	√				√				√	√									
Composite - Planned	√		√	√	√		√	√	√											
Total	4	3	3	4	3	3	4	4	4	3	4	2	3	2	2	3	2	2	1	2
Group										Intermediates				Novices						

The observations noted any definite changes in the mental reasons for selecting a different route, largely through comments made by the user and recorded onto the video tape, at the point where they were made, and in relation to the search they were in the process of doing. These were explored fully during the interviews with the discussion of their routes and in the later recall interview. Interestingly for the adults although some found it difficult to recall the content they were able to remember how they reached the information or the tools used, thus supporting the view that users are aware of their mental choices and can remember decisions. It may reflect the cursory view of information, although as they made the same navigation decisions at different points it was easier to recall their decisions for their route as these were repeated, rather than with single visits to specific sites.

16.6 Working strategy definitions

The distinction between the navigational patterns and the working strategies is a significant one. Each working strategy is now defined.

16.6.1 Orientation working strategy

The Orientation strategy was characterised by frequent short looks at resource items, which were usually arranged sequentially. This type of strategy was very fast and did not involve reading the screen content but represented a 'quick look and move on' approach. This technique was frequently seen in the first study and was particularly liked by children, especially the younger and less inexperienced ones, although quite experienced children also used it. Comparatively few adults used this strategy or used it for less time, although this was not confined to any particular adult group. Users employed it at various times to see if they had covered all the areas or all of a particular resource. In many cases though, the Orientation strategy was the only type of linear route that these users employed. All the users selected one of the two linear strategies (the quick Orientation or the Researching structured approach), at some time in their searches. A few users employed both these strategies, but these were often complex users who applied a whole range of strategies. The Orientation user's search method was a rapid or quick search, which covered a lot of ground at reasonably fast rates. It was a superficial method, was without depth, but was a common browsing method.

16.6.2 Researching working strategy

The Researching strategy was the most common strategy identified in the empirical work and was used by the majority of users (especially the children) taking part in all the sessions. This strategy was frequently employed with one or two other strategies, notably the Studying strategy, and for the expert Composite users, it was one of a selection of different strategies that they used. Children used it for longer and more frequently, and to the exclusion of all other strategies, than the adults. The strategy includes a wide-ranging search characteristic, which covered a lot of ground, but was not as fast as the Orientation strategy. It has slight depth, and could be used with the star navigation pattern, and it often involved searching on similar themes (e.g. a specific subject).

16.6.3 Studying working strategy

The Studying strategy was used by all the categories of users from novice to expert. More experts used the Studying strategy than the novices, and they did this for longer periods of time. Novices tended to use the basic orientation/ sequential working strategy for longer amounts of time and only used the Researching strategy for specific information searches. The experts often combined the Researching and Studying methods, using the Researching strategy to move quickly to a particular location, and the Studying one for investigating the subject in more depth. The Studying strategy was the second most popular strategy and was commonly used to investigate a subject further. This preference for investigating with the Studying strategy and using the hierarchical navigation pattern may be caused by the design of the chosen software for the empirical work, as Encarta encouraged a hierarchical approach by creating a definite tree structure for many subject areas. The Studying strategy is linked with two distinct navigation patterns 1) Hierarchical - often on same or a limited group of subjects, with little width but more depth, continuing in the same or similar areas and followed a major text source with links, perhaps to another associated tree, and 2) Hierarchical extra - in-depth searching, a few hot text links, possibly creating new links.

16.6.4 Composite working strategies - random and ordered

The Composite random strategy was relatively rare and difficult to recognise as this involved the user selecting and using a whole range of strategies in apparently random fashion. There were a few examples of this approach, where different techniques were used at random for short time periods. Many of the Composite users spent time planning how they would investigate the software and which methods they would use, and so would be classified as ordered. The random strategy involved the user checking where they had been, or using a range of different methods, but it was the erratic nature of this search that classified them as random. Certainly more examples of this strategy would need to be uncovered before it can be explained and described more fully. It may not prove worthwhile eventually to separate the random and ordered strategies, but they have been divided at this stage. It was also rare if the Composite-random user did not use some Composite planned strategies, suggesting that the random version may be a rapid version of the planned one. The Composite-planned strategy was more common than the Composite-random one and demonstrated the user's detailed knowledge of the software organisation. All the users of the Composite-planned method were experts and they were all competent computer and software users. These Composite users demonstrated excellent control of the resource, and an ability to know what to do and where to go, so used sophisticated techniques. It was necessary to have good control, and an awareness of both the system and the location of the information to use this strategy, attributes which the novices did not possess. The Composite working strategies are linked by in depth searches - wide-ranging and deep searches, having depth to all or part of the searches, following both hot text and other links as well as creating new links. It was more successful to regard these working strategies and associated methods of searching as a continuum and to place each individual's preferred methods in a broad band within the whole sequence. As these were recognised only from the second study and were only fully explored after the analysis of the data,

it is too early to make strong statements about these methods. There needs to be a systematic look at more users, with their navigation and working strategies analysed with the classification. As it is difficult to assess this retrospectively, this should be redone in future empirical research.
Table 16.3 (overleaf) lists each of these search methods and the users who employed them, together with the task and the classification they were given (from novice to expert). Additionally Types 1, 2 and 3 are used by all three classifications of users, Type 4 by intermediates and experts only, and Type 5 by experts exclusively.

16.7 Knowledge levels and user interests

Significantly, and not surprisingly, the users often used their own interests as a starting point for searching in the encyclopaedia. Most of the users started by checking for prior knowledge items. They used this as a branching off point for further searches, researched any new information, or followed up another lead that had caught their attention. Many users were self-deprecating about their experience level in using multimedia. Related to this, little information was given by the users on working methods they had used, either because they were not aware of using any or they did not know of any specific methods. Few users admitted employing any specific strategies for using multimedia, but wanted to know about effective strategies and gave positive comments on this aspect. Those with specific approaches in using multimedia included references to using the search facilities such as the tree search, trying different ways of getting at information, checking the overview first before moving into the resource, searching for keywords, and using the read-me file or the index. Different reasons for using specific strategies included: selecting strategies that were task, material or interface dependent, or topic-led approaches.

16.8 Designer issues - navigation patterns and working strategies

There were connections or associations between the navigational patterns and the working strategies that users employed. The experts' patterns and strategies were often associated but they generally used more patterns and strategies, and were usually able to determine the most suitable patterns for a specific task. The novices were more restricted and often remained with the one pattern or strategy they knew rather than try something new. The students that predominately used linear navigation patterns were the most likely to use Orientation working strategies. These linear navigators also used the Researching working strategy although there was a small overlap with the Studying strategy. The experts were willing to use Studying rather than Researching strategies, and linked more of the information to outside sources by way of hot text. There were again some individual preferences for particular working strategies, although these were not as strong as the preferences for navigational patterns and the working strategies were more restrictive and more rigidly applied with the novices, but less so with experts. Experts tried different working strategies with different tasks, and commonly used repeating techniques. There were fewer associations in the first study than in the second between the navigational patterns and the working strategies.

Table 16.3 Working strategies and search methods, tasks and types of user

Type 1 Orientation - delimiting	Type 2 – Researching - Wide ranging	Type 3 Studying - Hierarchical	Type 4 Composite Medium level, Random	Type 5 Composite – In-depth search, Planned
QB - Task 1 - Novice	QB - Task 3 - Novice	SX - Task 3 - Expert	CO - Task 3 - Expert	JP - Task 3 - Expert
DE - Task 1 - Novice	IT - Task 3 - Novice	QG -Task 3 - Intermediate	EH - Task 3 - Expert	NT - Task 3 - Expert
SX - Task 1 - Expert	DE - Task 3 - Novice	JE - Task 3 - Intermediate	BI - Task 3 - Intermediate	NL - Task 3 - Expert
CO - Task 1 - Expert	JP - Task 3 - Expert	JX - Task 3 - Novice	OE - Task 3 - Intermediate	KS - Task 3 - Expert
QG - Task 1 - Intermediate	NT - Task 1 - Expert	BT - Task 3 - Novice		NP - Task 3 - Expert
NL - Task 1 - Expert	KS - Task 1 - Expert			UP - Task 3 - Expert
JE - Task 1 - Intermediate	UP - Task 1 - Expert			
EH - Task 1 - Expert	BI - Task 1 - Intermediate			
JX - Task 1 - Novice	NP - Task 1 - Expert			
OE - Task 1 - Intermediate	TE - Task 3 - Novice			
BT - Task 1 - Novice				
TE - Task 1 - Novice				
IT - Task 1 - Novice				
KN - Task 1 - Expert				
+ Task 3 - Expert				

This could be explained by the fact that the first study was dealing with less experienced users, and that there was some variance in preferences within the pair. In both studies the novice users showed more restrictive use of both patterns and strategies. None of the first study participants used complex/ composite methods in either navigational patterns or strategies, although their routes were sometimes complicated and involved recapping, especially when one of the pair returned to their selection during their turn. The first study children were on the whole slower than the expert adult users (with the only notable exceptions to speed being the rapid clicking technique), but this slower speed may have allowed the navigation patterns to remain distinct and hence meant there was less need to classify combined patterns as Composite. The experts (and two intermediates) were the Complex patterns and Composite strategies users, however they were also termed Complex/Composite users when their use was so fast that it was difficult to differentiate pattern types. The experts had reached a distinct developmental stage in their skills and abilities, which the children and less experienced adult users had not yet attained. These findings affirm one of the key research questions, that is: Are there differences between different groups (children and adults, and experts and novices) use of navigational patterns? Differences in approach by the adults compared to the children have been highlighted and specific patterns have been re-used. It was possible to analyse techniques used by experts, and encourage novices to use the software in similar ways, which reduced the amount of time taken to become proficient at using multimedia.

16.9 User groups and the novice to expert continuum

The groups of users recognised in the second study may need to be subdivided as proposed earlier with subdivisions of the three main groups, novice, intermediate and expert. Looking at the charts from the individual adults (in Appendix 3) for each task, revealed a range of abilities and skills for each user. This would allow them to be placed on a continuum from novice to expert and they may present different stages of development related to their broad classification within their group. This gradual development of their skills and abilities together with the links of these to their knowledge acquisition and use would place them along the continuum. Work on the levels of attainment of individual users has been well researched. It was decided early on in this thesis research that the focus would be too broad if learning was included together with navigation patterns. Packham (1998) discussed levels or stages of learning and a short summary is relevant here. Packham's work on learning developed the concept of stages of learning. He suggested that there are three levels, which users can attain with their own learning. These are as follows:

Level 1 - Cognitive Level - Basic information processing, perceiving, reading, speaking

Level 2 - Meta-cognition - Monitor cognitive process

Level 3 - Epistemic cognition - Processes of individual events

He further explains these by stating that the Level I student has developed a window on the world, or a bag of tricks which they can take with them in the next learning activity. He speaks very highly of action learning, of learning while doing some activity. Level 2 learning is to an extent a continuation of Level 1, although attaining this level requires a conceptual jump to a newer meta-learning approach, which he terms learning about learning. He believes that if students are to take charge of their own learning then they must have the skills to do this and that these need to be taught. Level 3 is an even larger jump, and one that fewer students are capable of, or in some cases even aware of, which he states, is learning about learning about learning. Linking my research to Packham's (1998) three levels or stages of learning, most users were already at Packham's Level One, i.e. most of them in the second study, were able to collate facts and used them to navigate through the resource. Regarding Packham's Level Two fewer of the users attained this level, although some users had begun building their own links into the resource. Even fewer users had attained Level Three. Few multimedia packages at present would allow the full development of the Level Three processes. This would necessitate allowing users to create their own links in the resource, to introduce new material and to redesign the connections between the existing materials. These three levels are broadly comparable to the novice, intermediate and expert division. The specific divisions between each of Packham's levels become specific attainment levels and are a significant model for use in multimedia. My view is that the attainment levels are a more gradual progression and although distinct attainment levels can be reached the progression follows along a continuum. It may be possible that certain individuals never fully attain the status of expert, but most users should be able to graduate from novice to intermediate.

16.10 User issues - Comparisons between children and adult groups

Several of the comparisons between the first study and the second study have already been made, but it is informative to look at and analyse these issues collectively. The first study participants, on the whole, were new to multimedia and very enthusiastic about using it, but they lacked the experience and skills to do so. However there were differences between the child novices and the adult novices, as the children were much more prepared to try out different sections of the software and they were much more adventurous. Some of the more computer literate children, despite the fact that they were still novice users of multimedia, were beginning to show some of the techniques of the more experienced adults. These experienced users techniques were: scanning areas quickly, changing strategies and changing direction if they did not work. On the whole the younger children were more rapid users of the software, often being impatient, and rarely reading the text. However this was rarely the case with the older children, who usually read the text with care. The older children were also much more task orientated and very specific on the outcomes of the task. The younger children were much happier to browse. Browsing varied among the adults, some of whom asked if this was all they had to do, or if they had done it all, while others were not concerned. Some adults were concerned with whether they had done everything expected of them, while the children were more concerned if they had done, or found, the same as everyone else. Some of the adults disliked being observed, although few of the children were affected by the observations. Children were more used to being observed, although some children disliked being audio recorded. The amount of explanation of what they were doing varied considerably in each case. The tasks set for the first study were simpler than those for the second study, due to the younger age range, and user's inexperience with multimedia.

16.11 Summary of first and second study working strategies

1) Differences and similarities with choices of navigation patterns

The first study users had distinct preferences in navigation routes. In the first study users preferred Linear and Hierarchical patterns, with some use of the Star and Circular patterns, which were more common. In the second study the linear and hierarchical routes were most common but adult users employed a Linear and a Hierarchical pattern at different stages in the session.

2) Differences and similarities between the users employing several patterns

Few first study users used several patterns and none were Complex users. In the second study there were users of multiple patterns who were then classified as Complex users.

3) Differences and similarities between the two studies in the use of working strategies

With working strategies, most users in both studies used an Orientation or Researching strategy at some stage. Younger users frequently used the rapid Orientation style and used less of the Researching strategy than the second study participants. Only a few first study pairs used the Studying strategy, but this was very common in the second study.

16.12 Further analysis of Study 2

A further analysis of the working strategies in use in Study 2 was completed. This analysis involved calculating each user's time spent in each of the five working strategies (Orientation, Researching, Studying, Composite random and Composite planned). Table 16.4 gives the total time spent for each strategy, with ranges, and includes the average time for each strategy. The Studying strategy had the longest average time.

Table 16.4 Working Strategies and the ranges and averages time in minutes

	Range	Total	Average	Max	Min
Orientation	0-13	95	4.75	13	0
Researching	3-18	178	8.90	18	3
Studying	0-32	244	18.05	32	0
Composite Random	0	0	0	0	0
Composite Planned	0	0	0	0	0

Table 16.5 (overleaf) demonstrates each user, their level – Expert, Intermediate or Novice and the time in completed minutes in each strategy. The total represents the amount of time (from 25 minutes allocated) that the user spent on the task. The range of time on the task is from 19 to 42 minutes. Most users (18 out of 20) used the Orientation strategy but the majority of the users used this for a short time, Researching strategy was used by 19 out of 20 users and had a wider range with some users (6 of the 20) using this as their main working strategy. The Studying strategy was used by 19 out of the 20 users and was the major strategy for the most users (12 out of 20).

Table 16.5 Working strategies used in Task 2 (in complete minutes)

User	Level	Route	Or	Re	St	CR/CP	Total
NP	Exp	A	**2**	14	**10**	**0 / 0**	**26**
TE	Nov	A	**0**	**6**	16	**0 / 0**	**22**
BT	Nov	B	**0**	**7**	14	**0 / 0**	**21**
OE	Int	B	**3**	16	**0**	**0 / 0**	**19**
JX	Nov	C	8	**8**	10	**0 / 0**	**26**
BI	Int	C	7	**5**	14	**0 / 0**	**26**
EH	Exp	D	2	13	**10**	**0 / 0**	**25**
UP	Exp	D	2	**4**	17	**0 / 0**	**23**
JE	Int	B	**13**	**10**	**5**	**0 / 0**	**28**
KS	Exp	B	7	**7**	11	**0 / 0**	**25**
NL	Exp	A	2	**6**	18	**0 / 0**	**26**
QG	Int	C	5	**5**	32	**0 / 0**	**42**
CO	Exp	D	5	**3**	13	**0 / 0**	**21**
NT	Exp	C	**10**	**9**	**6**	**0 / 0**	**25**
SX	Exp	A	9	**8**	11	**0 / 0**	**28**
JP	Exp	D	4	11	**9**	**0 / 0**	**24**
DE	Nov	C	4	**4**	23	**0 / 0**	**31**
KN	Nov	D	6	**7**	16	**0 / 0**	**29**
IT	Nov	A	3	18	**4**	**0 / 0**	**25**
QB	Nov	B	3	17	**5**	**0 / 0**	**25**
Total			95	**178**	**244**	**0 / 0**	**517**

Key: Lev = level, Or = Orientation, Re = Researching, St = Studying, CR = Composite Random, CP = Composite Planned

Major working strategy	**Orientation**	**Researching**	**Studying**
	2	6	12

It is not surprising that there was no evidence for the Composite random or planned strategies as the users were forced to use certain patterns rather than allowing the users to chose their own which prevented them from being able to choose their preferred method of working as well. In addition the limited content of Task 2 and the wide range of the interest level within the user group, as well as their commitment to the task, further controlled their limited use of working strategies. The preference for specific working strategies does not appear to be restricted to any of the levels (except perhaps to novice) within the group.

16.13 Analysis of Task 2 for each route (A-D)

The analysis of Task 2 Second Study looked at each of the four routes in turn. These were reviewed in terms of: the time used, the off task time, the tools used, the navigation paths and working strategies used and any comments. Task 2 was the enforced route through Roman History and each user was asked to follow one of four routes through the resource. The first route was very linear, the second very heavily text based, the third hierarchical and the fourth more open. Each of the routes allowed progressively higher levels of user control, with the Route A giving the least and Route D the highest levels. Each route is discussed in turn (and detailed overleaf in Table 16.6). Five users followed each route.

Route A

The five users using Route A were 3 Experts and 2 Novices. A range of tools was used but all of them used the Timeline (the basis of the prescribed route), all of them used a linear navigation pattern and two used a hierarchical pattern as well (both experts). A range of working strategies was used. There was considerable movement along the route with returning, and moving forward repeatedly, being common practices. The Timeline enabled easy movement off task and consisted of picture icons on other subjects which some users found inviting. All users had some off task time but for three users this took over 25% of the time. This was concerning, considering the task was over a simple linear route, but may be explained by the lack of user control.

Route B

Route B, followed by 2 Novices, 2 intermediates and 1 Expert, was described as having a heavy text component. Different tools were used and although all users used a linear navigation pattern, other paths were used and a range of working strategies. Two users were off task for over 20 % of the time and some found the route very difficult, including two who left the task early.

Route C

Five users (2 Novices, 2 Intermediates, 1 Expert) followed Route C, which involved using specific tools such as Find Wizard and/or Pinpointer and allowed a reasonable degree of choice on what to look at and for how long. Three of the five users kept to the 25/26 minutes with the two others being slightly longer. Most of the users kept to the task, although one user spent 38% of the time off task. All the users employed both linear and hierarchical navigation patterns and a range of working strategies. Comments referred to the large text and information content, the speed of movement and the high degree of detail on the route.

Route D

Five users (4 Expert, 1 Novice) employed Route D. All the users employed the Timeline and/or Pinpointer, they all used linear and hierarchical navigation patterns and a range of working strategies – Orientation/ Researching/ Studying, although the amounts of these varied (see Table 16. for details). Most users moved through the text quickly and covered the specific areas they were interested in.

Table 16.6 (overleaf) lists each of the participants by the Route they took through Task 2 and the working strategies they used for the task in minutes.

Table 16.6 Working strategies in Task 2 by Task

User		Task 2 Route	Orientation	Researching	Studying	Total time
NP	Exp	A	2	**14**	10	26
TE	Nov	A	0	6	**16**	22
NL	Exp	A	2	6	**18**	26
SX	Exp	A	9	8	**11**	28
IT	Nov	A	3	**18**	4	25
BT	Nov	B	0	7	**14**	21
OE	Int	B	3	**16**	0	19
JE	Int	B	**13**	10	5	28
KS	Exp	B	7	7	**11**	25
QB	Nov	B	3	**17**	5	25
JX	Nov	C	8	8	**10**	26
BI	Int	C	7	5	**14**	26
QG	Int	C	5	5	**32**	42
NT	Exp	C	**10**	9	6	25
DE	Nov	C	4	4	**23**	31
EH	Exp	D	2	**13**	10	25
UP	Exp	D	2	4	**17**	23
CO	Exp	D	5	3	**13**	21
JP	Exp	D	4	**11**	9	24
KN	Nov	D	6	7	**16**	29

The table above (16.6) was developed from the more detailed individual results for each participant. These are given in Table 16.7 (overleaf – 4 pages) where each route is on a separate sheet. The information on each user is included as well as the time off and on task, the tools, navigation and working strategies used in Task 2 and a brief comment. The time totals give the minutes spent by each individual on the task. In Table 16.6 minutes were assigned to each of the working strategies by having a timed review through each of the videotaped recordings. This involved recognizing through the user's behaviour or comments during the session when they had changed to a different strategy and how long they continued to use this strategy. In the Orientation strategy, frequent changes were noted.

The Researching strategy involved some text reading and review, but the reviewing process here was fairly rapid and involved less text reading as it generally consisted of skimming over the text, however it was usually undertaken at a slower pace than the Orientation strategy. In the Researching strategy some links were followed and some investigation was made of specific subjects.

In the Studying strategy there was more text reading, sometimes note taking, less rapid skimming of text but more time spent in concentrated and in-depth searching and reviewing. This could take time and this time was usually spent in a limited number of areas and subjects.

Each occurrence of the strategy was noted in terms of minutes and these were then added together and rounded up to give the total for each strategy for each user.

TABLE 16.7 TASK 2 – ANALYSIS BY ROUTES – ROUTE A

	Level	Time Used (Mins)	Off Task (Mins)	Time on Task (%)	Tools used	Navigation Patterns	Working Strategies	Comment
1 NP	EXP	26	2 7.6%	24 92.3%	Pinpointer Timeline	Linear Hierarchical	Orientation Researching Studying	Fast, efficient
2 TE	NOV	22	6 27.3%	16 72.7%	Timeline Hot Text	Linear	Researching Studying	Moving backward and forward. Easily put off by other subject
11NL	EXP	26	3 11.5%	23 88.5%	More information	Linear Hierarchical	Orientation Researching Studying - Mostly	Slow speed Specific areas of interest
15SX	EXP	28	9 32.1%	19 67.9%	Timeline Online Features	Linear Hierarchical	Orientation Researching Studying	
19IT	NOV	25	11 44%	14 56%	Timeline Pinpointer	Linear Linear extra	Orientation Researching Studying	Moved away from prescribed area, backwards and forwards

Totals	127 mins	31 mins
Average	25.4	6.2

TABLE 16.8 TASK 2 – ANALYSIS BY ROUTES – ROUTE B

	Level	Time Used	Off Task	Time on Task (%)	Tools used	Navigation Patterns	Working Strategies	Comment
3BT	NOV	21	0 0%	21 100%	Further information	Linear Hierarchical	Researching Studying	'Heavy text component'
4OE	INTER	19	4 21%	15 78.9%		Linear	Orientation Researching Studying	'No activities available in package', critical
9JE	INTER	28	2 7%	26 92.8%	Timeline Find Event	Linear Circular	Orientation Researching Studying	Problems navigating, 'Getting lost'
10KS	EXP	25	4 16%	21 84%	More information Web Links Further Reading	Linear Extra	Orientation Researching Studying	Few links Rapid clicking to move around fast
20QB	NOV	25	5 20%	20 80%	Timeline Pinpointer	Linear	Orientation Researching Studying	Moved forward and backwards 'All text'

Totals	118	15
Average	23.6	3

TABLE 16.9 TASK 2 – ANALYSIS BY ROUTES – ROUTE C

	Level	Time Used	Off Task	Time on Task (%)	Tools used	Navigation patterns	Working Strategies	Comment
5JX	NOV	26	2 7.7%	24 92.3%	Pinpointer Find Wizard	Linear Hierarchical	Orientation Researching Equal Studying	Vast amount of info
6BI	INTER	26	2 7.7%	24 92.3%	Timeline	Linear Hierarchical	Orientation Researching Studying - Mostly	Reading text Too detailed
12QG	INTER	32	3 9.4%	29 90.6%	Find Wizard Pinpointer	Linear Hierarchical Star	Orientation Researching Studying - Mostly	Pinpointer Repeat Slow movement
14NT	EXP	25	5 20%	20 80%	Pinpointer Timeline	Linear Hierarchical Star	Orientation - mostly Researching - mostly Studying	Changes level frequently Comments Pinpointer movement
17OE	NOV	31	12 38.7%	19 61.2%	Timeline	Linear Hierarchical	Orientation Researching Studying - Mostly	Large text component
Total		140	24					
Average		28	4.8					

TABLE 16.10 TASK 2 – ANALYSIS BY ROUTES – ROUTE D

	Level	Time Used	Off Task	Time on Task(%)	Tools used	Navigation patterns	Working Strategies	Comment
7EH	EXP	25	6 24%	19 76%	Timeline Pinpointer	Linear Hierarchical	Orientation - Little Researching Studying	Frequent comments – boring, high text, prefer time line
8UP	EXP	23	0 0%	23 0%	Timeline Pinpointer	Linear Hierarchical	Orientation Researching Studying - Most	Little text reading – skimmimg - moving through, 'Get caught in areas'
13CO	EXP	21	4 19%	19 90.4%	Timeline	Linear Hierarchical	Orientation - Little Researching - Little Studying - Most	Timeline continuous, all areas discreet and arbitrarily placed
16JP	EXP	24	5 20.8%	21 87.5%	Pinpointer	Linear Hierarchical	Orientation Researching - Equal Studying - Equal	Off task on Civil Law – in depth study
18KN	NOV	29	7 24.1%	22 72.8%	Timeline	Linear Hierarchical	Orientation Researching Studying - Most	Timeline, some off task, slow machine affected navigation

Total	122	22
Average	24.4	4.4

16.14 Discussion

As the routes increased in complexity and in user choice the use of both navigational patterns and working strategies increased. Users found high text routes boring and disliked using these. Many users preferred using tools such as the Timeline. Users preferred to have more control and to have greater choice where they navigated. The off task time was frequently used for following links or following associated areas or following an interest (e.g. such as the Timeline). Designers of multimedia should be aware of the distraction possible because of the appeal of graphical based features such as the timeline and the Quiz, which may detract from more informed and educational uses of the multimedia package.

The analysis of the working strategies in each task and for each group proved interesting. In Task 1 the users employed their own individual methods for both navigating and working. In Task 2 the navigation route was prescribed and this changed some of the ways they chose to both navigate and work. This change in their preferences for patterns was also further confirmed in the third task, when users could revert back to the patterns and strategies used in the first task, use those from the second task or change to new methods for the third open task.

The degree of similarity over the topic areas, navigational paths used and tools used has been analysed under the stability inspection (Table 15.9, 15.10 and 15.11), which has investigated the re-use across Task 1 (the browsing task) and Task 3 (the open task). The stability across all three tasks has not been analysed specifically as Task 2 was a forced navigation route and not freely selected, as was the case with the other two tasks. However the re-use of techniques, patterns and strategies for Task 2 to Task 3 shows that when new techniques are introduced and used, these can be quickly taken up and applied to new areas.

In Table 16.5 it is clear that the novices spent most time on the Studying strategy (apart from two who spent more time in the Researching strategy), and relatively less time in the Orientation strategy. The intermediates were very varied and did not follow any particular group preferences and the noticeable feature of the expert's preferences was that they were general much more willing to try every strategy, or rather to use each strategy when they needed it. This enabled them to be much more flexible and to find more information and be quicker in their searches.

It was interesting to note that there were some users who re-used the enforced techniques of Task 2 into Task 3. The novice group was especially likely to re-use techniques, especially if they found them more useful or better then the techniques they had used previously. The experts however were less likely to re-use the forced patterns and in general were more prepared to adapt or use different patterns and strategies for each specific task. The experts would combine strategies, and change to a new one if this proved necessary (i.e. if they couldn't find information or found insufficient information on a particular topic). This ability to adapt to the requirements of the task was a significant attribute of the experts and one which would be difficult to teach/train novices in.

Finally the ability to both move between working strategies and to use relevant strategies for specific tasks appears to be developed to a higher degree by the experts and to a lesser degree by the intermediates, but is rare in the novices. This type of technique (or its development over time) would be a useful knowledge building tool for novices.

16.15 Conclusions

The working strategies chapter for the second study has found that each adult has preferences for specific working strategies. The range of working strategies used by the adults is more extensive and more comprehensive than that used by the children. The adults used all the classified working strategies. There are differences in the selection of different working strategies both by individuals and groups. There is a distinct progression through the types of working strategies with the experts being more adept and varied in their use of working strategies than the novices, in a similar way to their use of navigational patterns. This supports the view that it would be possible to show a developmental progression for the working strategies as there is evidence that certain working strategies are preferred by the novices and at the other end of the skills and abilities scale there are more developed preferences by the experts. Factors such as the increased speed of use by the experts need to be considered. The working strategies outcomes will be discussed in relation to the navigation patterns in the thesis conclusions.

17

Study 2: Lessons learnt

17.1 Introduction

The significance of this chapter on the Lessons from Study 2 is that it highlights the important issues of the second study and includes some analysis of these results. The major significant areas from Study 2 are that the adult participants all had specific navigation patterns preferences and followed distinct working strategies. It was possible to divide these users into three main groups and to analyse each of their routes through each of the three tasks and across all three tasks together. There were some group similarities or preferences, however once again these may have been a development of the greater skills and abilities of the user over time, which allowed the users to make better use of more complex and more difficult to use patterns and strategies. The analysis here is done under the perspective issues of designer and user, and the comparative use of each navigation pattern. Finally the chapter outlines the crucial points, which are covered in greater depth in the conclusions (Part V).

17.2 Designer issues - General navigational pattern comments

The results of the empirical studies indicated that most users have a preferred set of navigation patterns (Table 14.1). The most popular combination was linear and hierarchical patterns, which occurred across all levels of experience groupings, except for a few specific users who remained very linear. These strongly linear pattern users (mostly inexperienced users) were very methodical. This may reflect how they have been taught or the way they normally approach a specific task, i.e. sequentially. However this methodical and usually sequential approach may not be the most successful or appropriate one for multimedia. The work on the use of narrative in multimedia is relevant here, as the concept of the user needing a linked sequence of events or some definite structure within multimedia is significant, as this would imply the need for an overall story or structure to multimedia packages and that the user needs to be aware of this structure. The narrative research has already revealed that certain groups of users, especially novices, benefit from narrative structure. The difficulty with the narrative structure is that it might be too restricting for experts who may not be able to freely navigate in multimedia. This need for narrative structure may decrease as users increase their experience and skill. Table 17.1 (overleaf) lists the navigational patterns and working strategies used by each participant in the second study. There was a fundamental difference in how inexperienced users chose to begin/ navigate, compared to the experts. Novices favoured simpler, basic patterns. Intermediates were more adventurous but experts would branch out, try different strategies and use different patterns for each task.

Table 17.1 Comparison of navigational patterns and working strategies

Navigation	NP	EH	UP	KS	NL	CO	NT	SX	JP	OE	BI	JE	QG	TE	BT	JX	DE	KN	IT	QB
Linear	√	√	√		√	√			√	√	√	√	√	√	√		√	√	√	√
LinearExtra				√			√	√						√		√			√	√
Circular												√								
Star			√				√	√	√				√		√					
Star Extra			√				√		√											
Hierarchical	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√		√
Hierarch Ex	√			√				√	√											
ComplexCh	√									√	√									
ComplexPL	√		√			√	√	√												
Working St																				
Orientation	√	√		√	√	√	√	√	√	√	√	√	√			√	√	√	√	√
Researching	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Studying	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√			√	√
CompositeR	√	√				√				√	√									
Composite	√		√	√	√		√	√												

Intermediate users proved to be very variable in their preferences, but as there were only four users in this category, the results may have represented the sample range rather than the group. The experienced users generally used very complex routes, which may be explained by their selection of different strategies for particular tasks. These expert users employed many different patterns, but sometimes only for small amounts of time. The experts sometimes created incomplete patterns, and frequently mixed patterns, showing abilities in switching to different methods or changing their strategy. The expert's navigation patterns were less purposely followed, and more intuitive, especially if they reached a dead end. In these situations the experts were much quicker than the other two groups at re-assessing where to continue the search. This flexibility at being able to change direction and navigation technique was a key expert feature. The navigation routes that the users employed will now be discussed in detail. Table 17.2 compares the navigation patterns of the children in Study 1 with the adults in Study 2.

Table 17.2 Comparative use of navigation patterns

Navigation Patterns	First Study Children (pairs)			Second Study Individual Adults		
	Younger Group	Middle Group	Older Group	Novices	Intermed	Expert
Linear	5	9	7	7	3	4
Circular	2	1	4	0	1	0
Star	1	6	1	1	1	0
Hierarchical	2	8	8	5	3	4
Complex	0	0	0	0	1	5

Table 17.3 lists each of the main combinations of navigation routes employed by each user in the empirical work, demonstrating the specific individual's preferences for single or multiple patterns. This list is not exhaustive, as users, especially experts, exhibited short sections of other routes, which were insufficient in time and length to be separately classified. This expert user preference for rapid, short-term use of patterns within their navigation sequence has made these patterns difficult to identify separately and these patterns are classified as complex.

Table 17.3 Main combinations of navigation patterns all adult groups in the second study

Pattern Types	Users
Very linear, with little hierarchical pattern use	IT, QB (Novices)
Linear and Circular pattern use	IE (Inter)
Linear and Star, and some hierarchical	BT (Novice); QG (Inter)
Linear and Hierarchical	TE, JX, DE, KN (Novices); OE (Inter); KS, NL, EH, JP (Experts)
Complex and Hierarchical patterns used	BI (Inter)
Complex users	NP, SX, NT, UP, CN (Experts)

17.3 Linear navigation patterns

The linear route was the most common, although not the most used route in terms of time. Most users needed to have some sequential movement through the resource; this was especially noticeable with the novices. In the first study the linear option was the most popular route, and most users employed a linear pattern at some stage during their multimedia session. However in the second study the adults were less inclined to remain with this pattern. It was often used as a starting off point occurring at the beginning of the session or later on, when the user checked back to ensure coverage of all aspects of a specific area. When the user became more accustomed to the package, they used other navigation methods. The linear pattern was frequently used in conjunction with other patterns. In the second study it was not used exclusively, as in the first study with some pairs only using the linear pattern. The linear extra route was restricted to a few users and this pattern may be a variant of the main type rather than a separately defined pattern, but more users are needed to confirm this.

17.4 Circular navigation patterns

There were relatively few examples of the circular route with the adult users, but it was more common with the first study children. Users who employed the circular route for only a short time may not have been classified, due to the shortness of use and lack of completion of the pattern. The prevalence of the circular pattern with younger users, together with the star pattern, can be explained by their need to check that they had covered all available options. First study participants used the circular pattern as an orienteering device, to determine their current position and to assess the package, by having a short tour before returning to their initial starting point before continuing the search. The circular route was used at the start of the session and was used preferentially by some users, especially those with strong linear preferences. The linear and circular patterns were employed by the same users and were a popular combination only in the first study.

17.5 Star navigation patterns

The star was little used in the adult group and was much more prevalent in the first study especially with younger users. The star pattern was often used as a delimiter type of approach to find the limits of the package. It was typically employed by the user rapidly investigating several areas, frequently venturing down one level to view the contents, and then progressing on. It was used with other patterns, and with the first study children it was used with hierarchical rather than linear patterns. In fact this pattern was frequently associated with the hierarchical pattern and may have investigated greater depth in a subject. The star extra was relatively rare in the adult users, but more common with the children. The star pattern was used throughout the session with the adult users, for checking the section content, and for investigating the next level down to assess whether that area merited further investigation. The star pattern was used as a more developed way of finding one's way around the package with users employing it for sequential searching. The star extra pattern links areas by allowing the user to investigate down to the next layer of information.

17.6 Hierarchical navigation patterns

The majority of users used a hierarchical pattern, either using the basic or extra version at some stage during their session. The exceptions to this were the very linear preference novice adults and some first study children who rarely used a hierarchical pattern. The hierarchical pattern was employed by most users, in the middle of the search after the initial use of the linear or star pattern. The explanation for this was that linear and star patterns located the information, and the hierarchical pattern went further down into more detail. Some users were content to employ this pattern for most of the time, and continued with it once they had located the subject matter they wanted. Others used it to find a relevant link and then followed that, working hierarchically.

The hierarchical pattern was used to check what they had done, or to repeat relevant sections. This pattern was used in a hybrid form with other patterns, and hierarchical pattern usage was sometimes difficult to recognise unless followed for some time. The rapid hybrid users, where each separate pattern was used too briefly or too quickly to merit exact recognition, were classified as complex users. The hierarchical extra pattern represented more sophisticated use e.g. a basic hierarchical pattern was followed then the user moved across with some form of link, to another part of the same or associated hierarchy, before continuing on this branch. The hierarchical extra pattern was difficult to decipher, but was employed by users with strong preferences for the hierarchical pattern. Hierarchical extra users also occasionally returned up the tree where they had started from and then branched off down another route. This method of working back, or returning over the same ground, occurred after researching a topic, involved checking they had covered everything, or retracing another link that they had come across earlier.

17.7 Complex navigation patterns

There were two main variants of the complex pattern. These were termed complex chaotic and complex planned. The complex users were mostly confined to the expert group. There was no evidence of the use of complex patterns in the first study, although some users used mixed patterns. The chaotic users were quite rare and the planned users more common. The chaotic option was only used if a particular search failed to reveal anything, or if there was a link which was followed and then of little use. Most of the experts used complex patterns for some if not all of their session. They were prepared to change direction and use a different navigational pattern if one type was less successful, or if they came across a relevant link. In the expert group there was evidence for occasional use of the chaotic pattern, but this was usually fairly short lived and could be quite spasmodic. Most of the complex pattern users were quite well ordered and premeditated in their routes. Alternative routes were discarded rapidly as using complex patterns required knowledge, and experienced use, of other pattern types. Most complex pattern users also used other patterns. It is possible that the complex users were just hybrid users, as their high speed of use meant it was difficult or impossible to distinguish separate pattern types. The experts were more competent users and were much faster, covering a large area and making quick decisions, sometimes making mistakes and rapidly retracing their path to where they were last successful.

In synthesis, for the second study users, there was either a single, or a set of patterns, which each user selected in different quantities and for different amounts of time. There were three distinct variants, the first contained users who mostly used one main type and then only used another pattern to augment a specific search. The second variant used a limited range of two or three main pattern types, while the third variant employed a whole range of different patterns. These three variants closely paralleled the novice, intermediate and expert groups. This supports the view that the selection of patterns was related not only to personal preference but also to the user's skill and competence levels. The less confident user, who was new to multimedia software, tried less adventurous methods, while the experienced user experimented when navigating new software, in order to select the routes that worked best. However there were users who had very evident preferences for certain navigational patterns, and who employed these patterns every time, even if they did not produce a very successful search.

17.8 Linking the topologies with the navigation patterns

Further work was done on linking the topologies of the multimedia patterns with the navigation patterns, and the graphical movement required. The outline of two of the topologies (for Eyewitness History and for Encarta) is linked with two diagrams of the navigation patterns. This is included here (overleaf) as Fig. 17.1 and Fig. 17.2.

17.9 Lessons to take on to thesis conclusions (Part V)

The lessons for the thesis conclusions are that each individual child and adult has navigation pattern preferences. Each adult has different levels of skills and abilities and these can be broadly placed into three distinct groups: novice, intermediate and expert. It has been possible to create navigational charts for each user. Analysing these charts for each specific task has revealed an individual's range of preferred navigation methods. Each adult has a range of working strategies, and there are relationships between their choices of navigation pattern and working strategies.

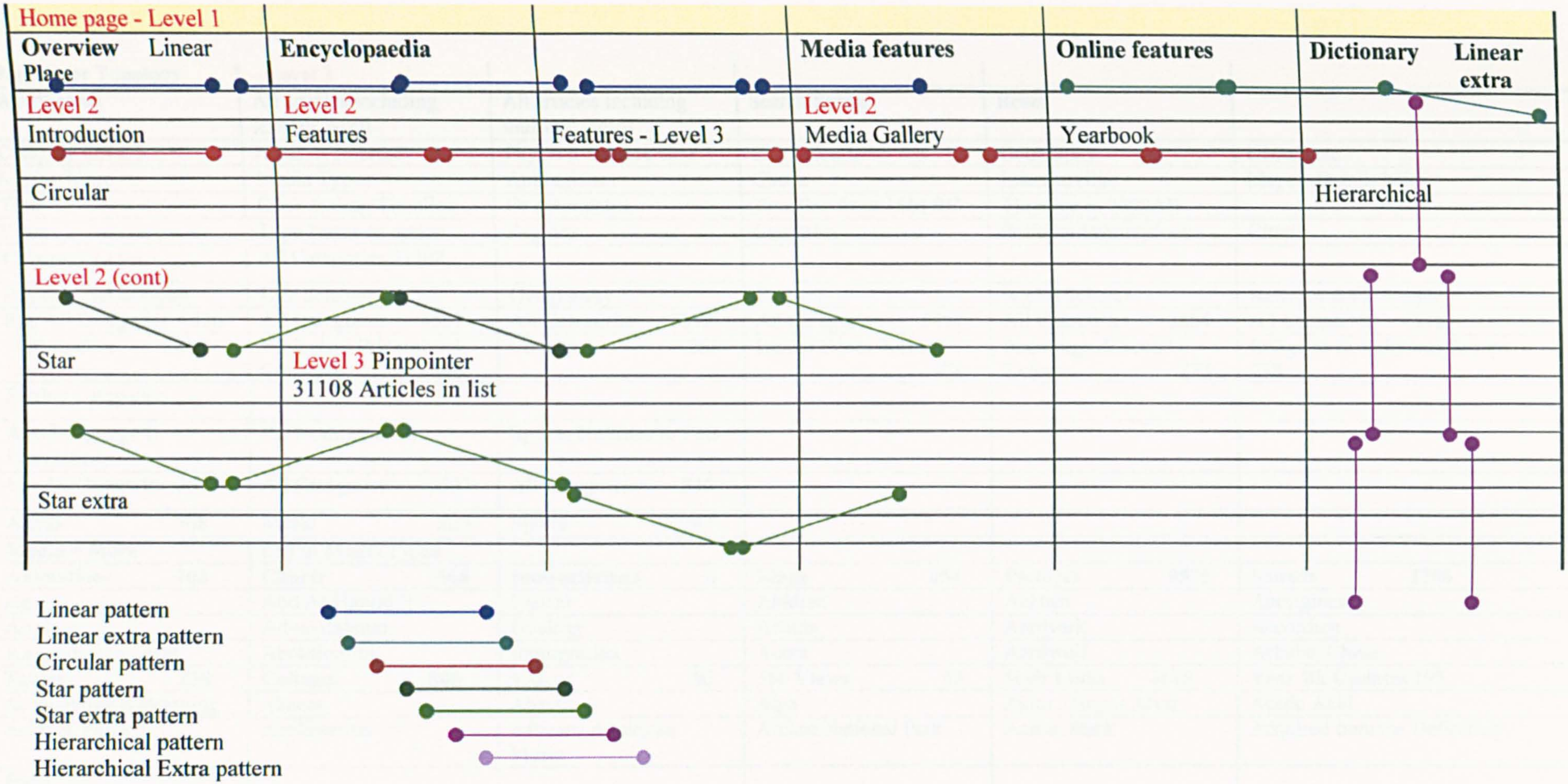
17.10 Conclusions

The second empirical work was successful in that it was possible to determine that each individual has navigational pattern preferences, and that these can be classified. In a similar way each adult user had preferences for distinct working strategies. If these individual preferences were more widely known this would help the designer develop more user friendly software and the user would be aware of their most satisfactory method for navigating and working. If preference based multimedia was more readily available it could significantly help the user's skills and abilities in using software.

Fig 17.1 and 17.2 Topologies and the related navigation patterns, for Encarta (17.1) and Eyewitness (17.2)

Home page - Level 1					
Overview	**Encyclopaedia Articles**		**Media features**	**Online features**	**Dictionary**
Level 2	Level 2		Level 2		
Introduction	Features	Features - Level 3	Media Gallery	Yearbook	Alphabetical List
What's new	Options	Media Features-	Inter Activities	Web Links	Search facility
Home Screen	Back	Interactivities	Guided Tours	Downloads	
Article Screen	Find	Guided Tours	Atlas	Encarta Online	
Searching	Home	Atlas	Timeline	World Wide Web Tips	
Links to WWW	Dictionary	Timeline	MindMaze	Online Library	
Monthly Updates	More Information	MindMaze	Collages		
More information		Collages		Tools	
Media Features	Level 3 Pinpointer	Online Features		Notemark	
Collages	31108 Articles in list	Yearbook		Browse Panel	
Using Articles	Word Search	Downloads		Word Processor	
Browsing for Fun	Category	Encarta Online			
Preferences	Media + More	World Wide Web			
Back/Next	Time	Online Library			
	Place	Tools			
	Wizard	Notemark			
	See Pinpointer below	Browse Panel			
		Word Processor			

Overleaf – Overlay sheet for Encarta Topology – to be placed on top of Navigation Pattern layout



Encarta package Overlay with navigation patterns

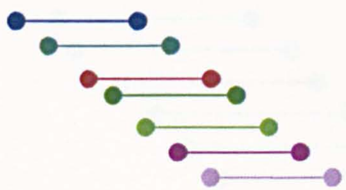
Encarta Package Levels within package

Pinpointer Topology	– Level 3				
WordSearch	All articles including specific word	All articles including multiple words	Search String	Reset	
Category Level 3	Areas of Interest	Physical Science/Geo	Life Science	Geography	History etc
Media+More	Media Types	Animations	Charts	Interactivities	Maps – Details below
Time	Click & drag Timeline	Or enter dates	Timeline from 15M BC	Timeline to 2000AD	
Place	Type Name or option	Regions	Countries	Political Subdivisions	Cities
Category Level 3	All Categories 31108				
Physical Sci & Geog	**Life Science**	**Geography**	**History**	**Social Science**	**Religion &Philosophy**
E.g. All Categories 4056	All Categories 4557	All Categories 7318	All Categories 5467	All Categories 3854	All Categories 2263
Mathematics 215 Level 4	Biological Principles & Concepts 906	Countries 261	United States History 402	Sociology & Social Reform 273	Religions & Religious Groups 238
Further Categories					
Art, Language & Literature	**Performing Arts**	**Sports Hobbies & Pets**			
e.g. All Categories 3571	All Categories 1797	All Categories 946			
Artists 768	Music 225	Sports 247			
Media + More	List of Media Types				
Animations 103	**Charts 566**	**Interactivities 8**	**Maps 654**	**Pictures 9575**	**Sounds 1206**
e.g.	Abd Al-Hamid II	Fractal	Abidjan	Aachen	Aborigines
Airplane	Ad-ar-Rahman	Geology	Acadia	Aardvark	Accordion
Alexander the Great	Abolitionists	Immigration	Accra	Aardwolf	Achebe, China
Tables 238	**Collages 805**	**Videos 93**	**360 Views 53**	**Web Links 4648**	**Year Bk Updates 197**
AccountingBookkeeping	Abacus	Abacus	Alps	Aalto, (Hugo) Alvar	Acetic Acid
Acids & Bases	Abolitionists	African- American Music	Arches National Park	Aaron, Hank	Acquired Immune Deficiency
Time					
15M BC 144	**2000 - 1000 BC 134**	**500 - 1000 AD 1301**	**1250 - 1500 AD 867**	**1650 - 1800 2379**	**1900-2000 10759**
Albertosaurus	Abraham	Africanus, SextusJulius	Aakjaer, Jeppe	Abd Al-Hamid 1	Aakjaer, Jeppe
Allosaurus	Aegean Civilisation	Agatha, Saint	Aalto, (Hugo) Alvar	Abel, Niels Henrik	Aalto, (Hugo) Alvar
Place					

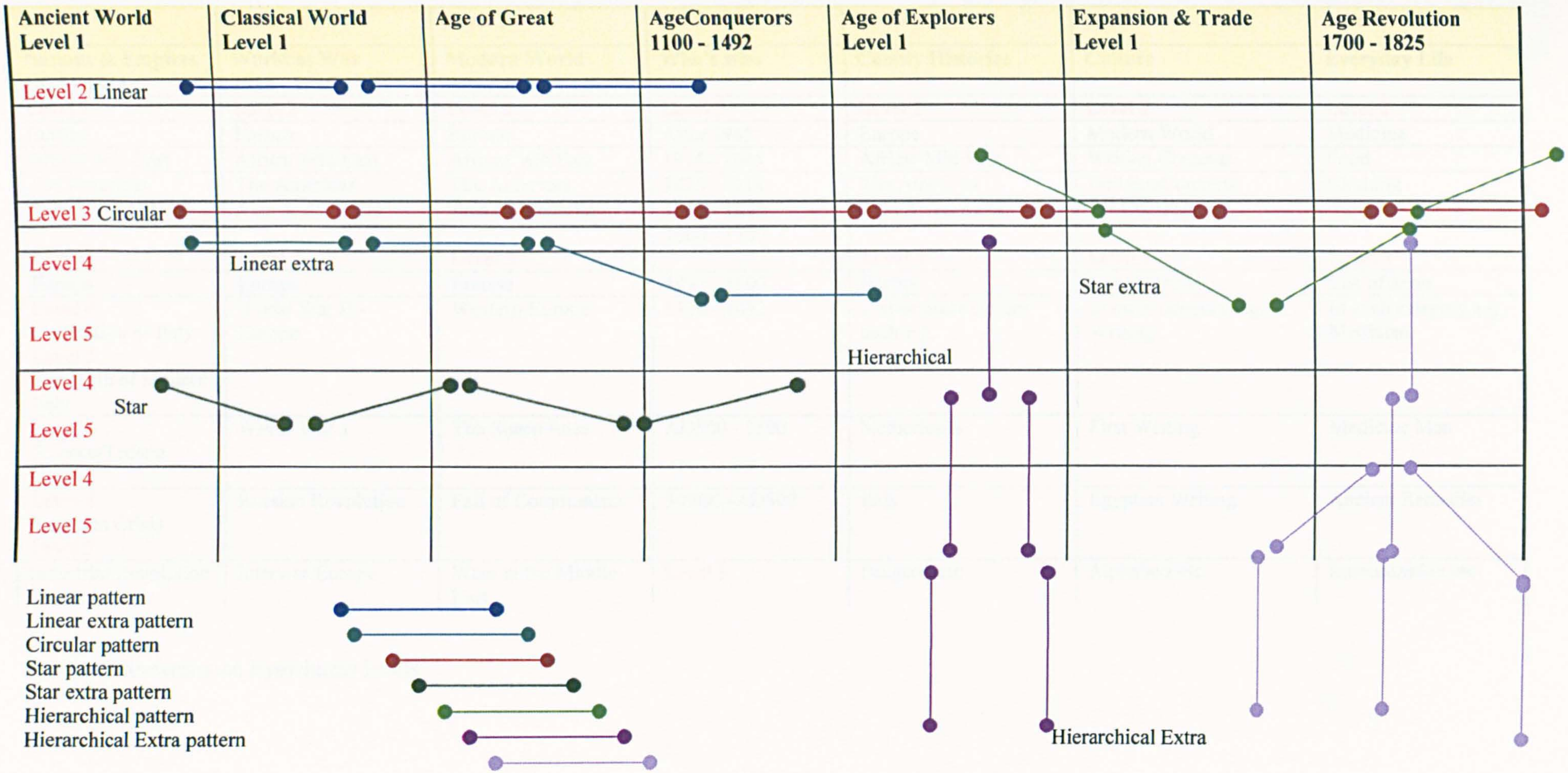
Encarta Package Levels within package

Ancient World Up to 500 BC Level 1	Classical World 500 BC - AD 50 Level 1	Age of Great Religions AD500 - 1100	Age of Conquerors 1100 - 1492	Age of Explorers 1492 – 1600 Level 1	Expansion & Trade 1600 – 1700 Level 1	Age of Revolution 1700 - 1825
Level 2 E.g:	Level 2	Level 2	Level 2	Level 2	Level 2	Level 2
Prehistoric World	Europe	Europe	Europe	Europe	Europe	Europe
Level 3	Level 3	Level 3	Level 3	Level 3	Level 3	Level 3
Prehistoric World	Europe	Europe	Europe	Europe	Europe	Europe
Level 4 Plains Hunter- Level 5 Primitive Weapons The Mammoth	Level 4 Roman Life Level 5 Roman House Centre of Empire	Level 4 Vikings &Normans Level 5 The Viking World Memorial Stone	Level 4 Re-conquest of Spain Level 5 The Reconquista	Level 4 Tudor England Level 5 Shakespeare's Theatre Spanish Armada	Thirty Year War Siege Magdeburg Causes Thirty Year War The Treaty of Westphalia Sweden's Role in the War	Level 4 Russian Conquests Level 5 Growing Empire Balailaika
Level 4 The First Humans Level 5 Human Development	Level 4 Roman Empire Level 5 Roman Expansion Roman Legionary	Level 4 Monks & Monasteries Level 5 Lindisfarne Gospels	Level 4 Medieval Europe Level 5 Magna Carta Towns & Fairs	Level 4 The Renaissance Level 5 Leonardo's Love of Learning	Level 4 The Sun King Level 5 Life at Court Louis XIV's France	Level 4 Rise of Prussia Level 5 Prussian Success Enlightened Rulers
Level 4 The First Farmers Level 5 Fertile Crescent Catal Huyuk	Level 4 Greek Civilisation Level 5 Greek Invention Hellenistic Culture	Level 4 Feudal Europe Level 5 Domesday Book Feudalism	Level 4 Hundred Years War Level 5 Longbow	Level 4 The Reformation Level 5 Wives of Henry VIII Reformation of Church	Level 4 Scientific Revolution Level 5 Clockwork Universe New Science	Level 4 Power & Productivity Level 5 Farming Steam Power

Linear pattern
Linear extra pattern
Circular pattern
Star pattern
Star extra pattern
Hierarchical pattern
Hierarchical Extra pattern



Eyewitness Package Topology with Navigation Patterns – Main levels



OVERLAY FOR Eyewitness Package, Navigation Patterns over Topology PAGE 1

Level 1	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1
Nations & Empires 1825 - 1914	**World at War 1914 - 1945**	**Modern World After 1945**	**Who's who**	**County Histories**	**Culture**	**Everyday Life**
Level 2	Level 2	Level 2	Level 2	Level 2	Level 2	Level 2
Europe	Europe	Europe	After 1945	Europe	Modern World	Medicine
Africa/ Mid East	Africa/ Mid East	Africa/ Mid East	1914 - 1945	Africa/ Mid East	Writing Contents	Food
The Americas	The Americas	The Americas	1825 - 1914	The Americas	BuildingContents	Clothing
Asia & Australia	Asia & Australia	Asia & Australia	1700 - 1825	Asia & Australia	Art Contents	
Level 3	Level 3	Level 3	1600 - 1700	Level 3	Level 3	Level 3
Europe	Europe	Europe	1492 - 1600	Europe	List of items	List of items
Level 4 Unification of Italy Level 5 The Birth of Modern Italy	World War II - Europe	Western Europe	1100 - 1492	List of places under each e.g.	In each category e.g. Writing	In each category e.g. Medicine
Level 4 Science/Techno Level 5	World War 1	The Space Race	AD500 - 1100	Netherlands	First Writing	Medicine Man
Level 4 Russia in Crisis Level 5	Russian Revolution	Fall of Communism	500BC–AD500	Italy	Egyptian Writing	Ancient Remedies
Industrial Revolution	Interwar Europe	Wars in the Middle East	Level 3	Bulgaria etc	Alphabets etc	Immunization etc

Further information on Eyewitness levels

Part V Conclusions

Part IV Contents:

18

Outcomes and issues

18.1 A summary of the navigation issues

The chapter assesses the key questions of this research, (outlined in the introduction 1.9), and the subsequent hypotheses, puts these into context, and relates these questions to the empirical study findings. The thesis has addressed the main research question - Do individuals have distinct preferences for certain types of navigational patterns? The focus of the research is how to discover the preferences users have for navigational patterns and the variations in these choices between both individuals and groups. The key facts from both the first and second studies are reviewed as well as the designer and user perspectives. The chapter relates back to the navigation charts (in Appendix 3, Charts 15.1-20, linked into the Navigational Patterns Chapter) as a means of analyzing and comparing the navigation patterns. The relationship between the first and second studies, in particular the differences between the children's and adults' usage of multimedia is discussed. Additionally the subsidiary questions are discussed, i.e. whether or not these preferences are 1) affected by the system and navigation design, 2) related to the user's working strategies and 3) different for distinct groups.

McKnight, Dillon and Richardson (1990) proposed that further empirical work was needed to uncover difficulties in navigation and that little research has been done to understand concepts such as navigation. Much of the research on navigational patterns could and should inform the designer of potential structures of new software. The user's preferences for different navigational routes indicate that software should be designed with a range of different formats available, to allow maximum flexibility for the user. The research has also shown that both age and ability levels have different requirements.

Children in this study tended to prefer linear or hierarchical patterns and variants of these, such as the star and circular pattern. However as the range of use was limited in the first study it was decided to change the focus of the second study to adults, so that this would enable a wider range of skills and abilities to be accessed, with the prospect of obtaining a wider range of preferred navigation patterns and working strategies.

Adults did use a much greater range of patterns, although most adults still used basic linear and hierarchical patterns. While none of the children used the complex methods, some of their patterns were fairly complicated. These more involved patterns may have been the result of children working in pairs, which made the actual patterns more complicated than they would have been with two individual searches. Adults did develop complex patterns although these techniques were largely confined to the expert users.

This supports the view that complex use of multiple patterns is a sign of the maturity of skills, and that the use of complex patterns demonstrates a sophisticated use of pattern types. However complex patterns are difficult to subdivide, due to the speed and rapid change techniques employed by the expert user. The range of ability and skill was large within all these groups. Some users were in a borderline situation (between groups) and exhibited variable skills within the tasks, which if they had been more consistent would have allowed them to be classified into another group. These difficulties are noted in the division of the different paths that adult users took through the package, when each of the three tasks is analysed and grouped (Appendix 3, Charts 15.1-20). It was also noted, especially from the children's perspective, that there were distinct preferences for types of interface, such as different icons, graphics and colours. This was especially true of specific multimedia packages, which have a restricted age range with a distinct cut off point in terms of interest. This cut off point phenomenon was prevalent in the children's perception of the software being too young for them, such as the Peanuts interface or too adult, for instance the Medieval Realms package. This delineation of the suitability of the software for the age group also occurred with The Way Things Work as although there was informative content for older children, the children themselves considered the cartoon type interface made the software package too young for them to use. There was little evidence for testing of software products by the multimedia producers with their proposed suitable age groups.

18.2 Thesis User aspect - Types of user and their individual styles

It is reasonably straightforward to develop from the user's navigational patterns their preferred working style. Groups of users can be typified especially if they preferred complex or mixed mode navigational patterns. An analysis of a particular user's path would enable them to be categorised as a certain type of user. For example, if they mostly use the index, they prefer a linear and structured approach, but may need context sensitive help using the index efficiently to progress and the route forward could be programmed according to their preferences. The concept of a continuum of experience is relevant as each user moves along the sequence, in terms of experience and knowledge.

18.3 Thesis outcomes - Beneficial features for quality multimedia

The features that greatly benefit multimedia are listed below. This list gives an overview of the necessary component parts of good quality interactive multimedia; detailed in Chapter 19. All these features have been considered at various points in the thesis (and these occurrences are listed in Table 18.1 overleaf) but it was deemed useful, both for the thesis and from the point of view of the guidelines for designers, to bring all these components together into the discussion section. All of these items have already been discussed at several points in the thesis. In some cases the references are very numerous and in these cases just the most relevant sources of these features are listed. The table is considered important as it pulls together the comments on each of these features and shows that consideration and discussion of these features has taken place through the thesis.

1. Navigational tool Diagrams or Map
2. Known material
3. History
4. Audit Trails - navigational paths
5. Time line
6. Activities - Worksheet/ Tasks
7. Index
8. User levels
9. Individual student records/personal histories
10. Customobility issues
11. Curriculum/ research links
12. Off-line facilities
13. Internet links
14. Expert guide, induction/introductory tutorial/tour
15. Intelligent Tutor

The table also supports the need to have these features and to produce a list of them as guidelines as they have been used by different researchers in a range of different multimedia but have not been brought together and discussed as a set of guidelines for future design work.

18.4 Thesis user aspect 2 - Intelligent tutor concept

From these requirements there develops a need to expand these further into a full Intelligent tutor system which is built into the multimedia software, again aimed at the individual and with an objective of developing the individual's skills and abilities. The concept of an intelligent tutor was first introduced in the thesis in the introductory chapter (1.9) and discussed in relation to Suchman's work in Part II, and again when discussing navigational patterns in Part III (Chapter 10, 10.8) together with best routes for user's, the provision of navigational help and the use of navigational maps to aid users, but again it was felt useful to bring these comments together. There is a need for continued research on intelligent tutoring systems and I have set out the specific requirements for an educational multimedia system in the implications for practice chapter (Chapter 19). One aspect of the research on intelligent tutor systems is that of learning. Various references have been made to learning throughout the thesis, however the focus was determined early on in the research and including learning would have both broadened and expanded the thesis beyond what was feasible within the time frame.

The learning references include: Plowman et al. research (MENO project, 1999, 3.4), Wright and Likorish on user's choice of less demanding routes (1994, 3.5), McGrath's work on learner control (1992, 4.4), Mischanchuk and Schwier (1992, 11.5) on learning using audit trails and Canter, River and Storrs (1985, 4.2, 11.8) whose five search strategies were related to ways of learning. These are by no means exhaustive and other references such as that of Oliver were concerned with educational environments and learning with ITS and there are also many internet sites which give background information on learning styles and link into the extensive literature on this subject (an example of one of these sites is: www.support4learning.org.uk/education/lstyles.htm). It was not considered necessary or feasible to develop this any further at this stage.

Table 18.1 Beneficial features for quality multimedia – references in thesis

Multimedia Feature	Main references for this in Thesis	Additional references
Navigational tools/ Diagrams or Maps	2.5, 3.8 – 3.12, 4.8, 11.7	18.4, 18.7- 8, 19.4, 19.9
Prior knowledge/ Known material	1.2, 1.7, 2.7, 3.10-14, 4.7, 5.1, 7.0, 7.18-20, 9.6, 9.10	9.17- 9.19, 14.4, 15.4, 15.12, 16.7
History	2.2, 3.3, 3.4, 10.8, 15.4	19.2, 19.4, 19.8
Audit Trails - navigational paths	2.16, 3.13, 11.5, 18.6	
Time line	9.17, 10.3, 16.13	7.17
Activities - Worksheet/ Tasks	7.12, 7.19, 9.19, 11.3, 12.6, 15.16	
Index	1.3, 2.1, 3.5, 3.8, 5.3, 7.4, 8.6, 8.9, 9.8, 9.17, 9.21	11.8, 16.7, 18.2, 19.4, 20.9
User levels	1.2, 2.6, 3.7, 3.12, 7.7, 7.21, 8.7, 9.16, 10.7, 11.13, 12.3, 12.6	17.2, 17.7, 18.1, 20.10
Individual student records/ personal histories	3.1, 6.6, 11.3, 12.3, 13.7, 14.4	18.6, 18.13
Customobility issues	1.2, 14.4, 18.6, 19.3	
Curriculum/ research links	8.3, 13.10	
Off-line facilities	8.2, 12.6	
Internet links	14.3, 20.5	
Expert guide, induction/introductory tutorial/tour	3.8, 3.11, 3.14, 7.6, 7.12, 8.2, 8.8, 17.4, 19.8	8.2
Intelligent Tutor	1.9, 10.8, 18.4,19.8, 19.11, 19.15	7.4

18.5 Designer issues - Research on navigation patterns

The literature review detailed existing research on navigational patterns, which now needs relating to the empirical research findings. The main research evidence that I investigated looked at navigation in four different ways: using navigational *software*, using navigational *strategies*, using navigation and guidance *tools*, and using *indices* to determine navigational patterns.

18.6 Designer issues - Using navigational software

The use of navigational software to investigate navigation patterns was employed by Horney (1993). Horney commented that having a strategy implies the existence of goals, objectives and motivations, but this is not always the case with educational multimedia. My research work firstly set out to explicitly investigate users' preferences in a free choice situation. Secondly the research examined both the impact on the user of constraining navigational choices and then determined the extent to which the user maintained their original preferences in subsequent tasks. The results showed that users do have distinct preferences but these can be changed or adapted if they are forced to use set navigation paths. This supported Horney's assertion that:

> Reader navigation is constrained by the prior decisions of authors who force readers into particular styles of navigation (p.267).

This raises another issue of whether or not designers and users are aware that the design and structure of multimedia may constrain the navigation patterns possible within the resource. This awareness of these issues is significant as users may not be able to use their preferred navigation patterns if the package does not allow this flexibility. The users need to be aware of their own navigation preferences and the designers need to have considered the navigation patterns that a range of users would want to employ. Horney also reported that his hypertext users followed distinct navigational patterns and he demonstrated these with trails and graphical representations of their routes. Horney also distinguished between these navigational patterns, and working strategies, such as scanning and browsing. This thesis has investigated this dichotomy and the discussion chapter will explore:

1. The way users navigated through the software – the physical dynamics of moving through the resource – navigational patterns, and
2. The way they work through it – the mental processes of the user – the working strategies and the search methods.

These two elements and a third one of how they interrelate form the main findings. These findings have been explored from the individual user's point of view and each specific user's route and their comments have been examined to deduce these three core elements. The existence of the two different aspects of using software is critical and will be further investigated in the analysis of the research evidence. In the group of researchers who employed navigational software, Mischanuk and Schwier (1992, cf.3.8) investigated audit trails and found four main types. These they classified as linear, classic feedback loop branching, learner controlled parallel path branching, and multimedia/ hypermedia. Misanchuk and Schwier were positive about audit trails use, stating:

> Audit trails in hypermedia fit the increasingly popular paradigm of naturalistic observation in that they are collected unobtrusively in a natural setting...The instructional developer, given this orientation, is charged with designing a rich context within which learning can occur (p.361).

This rich context was, I felt, a critical consideration in my research, and the research methods were intended to promote this by using individual observation sessions. It was essential that the observations of the empirical work did not interfere with the user's navigation through the multimedia. My research allowed such patterns or usage to be defined by using the scanned records. The charts created from these records, gave each individual a distinct path for each of the tasks within the empirical work (see individual charts, Appendix 3, Charts 15.1-20). Mischanuk and Schwier also gave reasons for developing research into audit trails, although their work concentrated on methods used and they gave little advice on exactly how to use these audit trails. They identified four uses for audit trails: data collection devices for evaluation, tools for basic research, determining the most interesting paths for certain classes of users and finally using the trails for counselling or advising users. It was these last two uses, finding the most interesting/ effective paths and advising the user on potential paths that have the most resonance with this research. These link into the thesis outcomes listed above (in 18.3) with audit trails and with personal histories for users, which are further detailed in Chapter 19. The facility for users to compare paths with previous users, and to discover which paths were the most rewarding, was vital as it allowed the individual more control over their own progress and allowed them to select their own most appropriate navigational pattern.

18.7 Designer issues - Using navigational strategies

Parunak's (1989) research can be related to Horney's as he also divided these two elements, navigational patterns and working strategies. His work covered three main aspects. Firstly he articulated navigational strategies in terms of their physical navigation. Secondly he related these strategies to graph topologies, and thirdly he analysed common hypermedia mechanisms (ways of using hypermedia) in terms of their navigational strategies and graphs. His research involved using a second method of analysing navigation using navigational strategies. He differentiated between navigational strategies, which he called Identifier, Path, Direction, Distance and Address, and his topologies, which he termed Linear, Hierarchy, Hypercube, Hypertorus, Directed Acyclic Graph (DAG) and Arbitrary. He also linked the topologies to the navigational strategies that they supported. Parunak proposed that information on beaten paths, or known or best-used routes would be productive. He stated that it was necessary to keep a history of where the user has been and the maps to illustrate this. It has been stated earlier that his topologies were closer than his strategies to my interpretation of the navigational patterns. But by dividing the methods of working with hypermedia into strategies and topologies it is significant that he differentiates between the method or style of navigating and the paths taken. Parunak related his aids to navigation with a topographical model and proposed using geographic links between the methods of navigating and where the user navigates. A practical way of doing this would be to create a map of the software as in games software and show both the method used and where the user is positioned within the resource. Again the provision of a map or diagram is listed on the proposed guidelines for developers for producing good multimedia (Chapter 19). Linking full mapping and navigational tools is an added facility for all software based on setting individual nodes for each item of information and linking this into a navigational matrix. This is a major area of my future research and a real potential link between multimedia and educational as well as user preference software, linking designer and user issues in a constructive and progressive way. Researchers such as Canter (with Rivers and Storrs 1985 and Powell, Wishart and Roderick 1986) proposed relating geographical techniques such as landmarks and maps or compass finders into multimedia packages to support user's orientation. The empirical study users managed successfully without these landmark aids, (although these may have benefited them) by using search techniques to develop this awareness for themselves, e.g. using the orientation strategy or the circular or star navigation patterns to determine boundaries.

18.8 Designer issues - Using navigational tools

The empirical work in this thesis has shown that users covered different amounts of information in each of the four routes through the same subject area. Different amounts of time were taken both to find the relevant material and to be satisfied that the search was complete. This is consistent with Trumbull, Gay and Mazur's (1992) research on using navigational and guidance tools to aid navigation. Their study assessed five aspects of the student's use of the system using the Bughouse system and a series of guidance tools. The student's awareness of where they were navigating and how much they had covered of the relevant material was significant. Additionally the use of the house metaphor enabled the students to position themselves and to 'map' their way around the house and its contents. This relates to Parunak's research that tried to give geographical markers to aid navigation.

18.9 Designer issues - Using navigational indices

The fourth approach to investigating navigation patterns involved the use of indices. Canter, Rivers and Storrs (1985) distinguished between indices that they termed path, ring, loop and spike; and search strategies such as scanning, browsing, and searching. They produced a series of graphs of the nature of the navigational paths, describing each of the main types. Canter et al., stressed the importance of individual differences, and demonstrated this with two expert users with different approaches. One of these would be methodical and the other erratic but inspirational. Canter et al. contested that both may be successful in achieving their aims in a database and they considered users would be more effective in a software environment that was sympathetic to their individual styles. An understanding of the navigational behaviour of the user they considered must precede the design of such tailored systems. Canter, Rivers and Storrs approach was very relevant to this thesis, and two features came out of their research. Firstly the need to specify the path and look at search strategies, hence distinguishing between the navigation patterns and working strategies, which has been highlighted as significant in this thesis. Secondly they stressed the importance of the user as an individual as well as differences between users, which are critical areas of this research. Although the different approaches to the study of navigational patterns have produced a range of arguments, these four research issues – using software, strategies, tools and indices to help determine navigational patterns are all relevant to my research. The research results were consistent with the two main findings of my research, firstly the need to assess each individual user's preferences for both navigational patterns and working strategies- user's perspective and secondly the need for designers to understand and support the individual's use of multimedia, the designer's perspective. The hypotheses are examined and the evidence to support them is assessed before the user perspective is discussed in terms of the individual user issues.

18.10 User issues - Discussion of the expert to novice divisions

The finding that Baeker and Buxton (1987) made that experts are so practiced and used to certain situations happening that they impose minimal loading, is supported by the empirical work for this thesis. Many of the expert users decided what to look for and began navigating to do this without much hesitation, and without necessarily considering the exact way to navigate in advance. This would support the view that they do comparatively little advance thinking of how to investigate a particular topic, but do it almost intuitively and therefore, although possibly unintentionally, take the easiest option – the minimal loading concept. The only exception to this was with the users who had to use a slower machine, this not only affected their navigation, but it also made them consider carefully where they navigated to, and decided to avoid any potentially highly graphic areas as they realised these would take longer to investigate (due to the slowness of presentation to the screen). The novices were much slower, more cautious, and less sure of themselves when they did set out on a particular path. Also the experts had a much faster awareness of when they had taken the wrong route or not the most appropriate route, and had greater abilities to correct this. McGrath's (1992) research on the novice/ expert divisions found that novice users viewed a lot of screens for short amounts of time. This rapid clicking phenomenon was seen with novice users, who used it to locate or orientate themselves, or to find a particular screen. It was noticeable with younger users, and was sometimes used excessively.

McGrath (1992) also related user's abilities to user control issues, and her research confirmed that low ability learners did not do well under a high degree of user control. These findings were supported by the results of my first study, but have less applicability to the adults in the second study. The adult's ability levels were less easy to assess and more comparable across the whole adult sample. My research results differed slightly from those of Scardamalia et al., (1989) as they pointed out that naïve/ novice students showed a strong tendency not to go back over information. Whereas in my research novices returned to check that they have seen all the relevant screens, they rarely re-read them. It should be remembered though that the observations in this thesis for the second study did not test for ability, apart from the self-assessment of the user's own level of expertise in the pre-test questionnaire. Selecting the users for the second empirical study from the volunteers meant that a range of users were selected, mainly by means of a brief description of their computer use and their job functions. In the first study the teacher assessed the user's ability and this was linked with their experience and concentration levels.

It was considered essential to select a range including beginners, users with some computer but no multimedia experience and computer/ multimedia professionals, for assessing the navigational preferences. The experts though would go back, re-read or re-analyse information in the light of new material. This was more of a process of sorting and prioritising information and producing a review or interpretation of it. The novices were usually more concerned with fact gathering, and with having covered all the available sections, but they did not attain the breadth and depth of knowledge of an expert. This was valuable as it supported the original intention to use a range of users from novice to expert, but that there are very real differences between these and that there may be users with very slow progression from novice to expert. This supports my contention that there is a continuum of users and that although novices and experts are at opposite ends there are grades of users in-between, which may mean that there are more potential divisions in the continuum or that the progression is gradual and continuous. At any point in the use of multimedia a user could have reached a specific stage in their development, and each multimedia use should improve their position along the scale. The expert users varied from the intermediate group, as the intermediate users have some expert attributes, although obviously not all.

The differences could be explained by the importance of understanding specific criteria or the need to know, which discretionary users (like the intermediate users here) did not have.

18.11 User issues - Evidence for recall in the empirical work

The analysis of the post observation questionnaires and interviews provided evidence of recall. The information retention, and the ability to recall it, was very variable and differed across the users. The degree of recall varied from fairly low levels to accurate and detailed recall of the whole session. Allinson and Hammond's (1989, cf. 3.9) research on recall found that the students' breadth of recall did not match the breadth of actual usage in the software. This has certainly been the case in these empirical studies. Some users, especially the experts, were concerned about their lack of recall and amazed at how little they did recall. Other users put this in perspective by considering that if they had needed it for their own work or research, or if they had had triggers or pointers or even more time, or they had chosen the subjects themselves, they would have remembered more. This point was certainly true with the third open task, where the users selected the topic and the recall was much better. These comments fit into Gagne and Glaser's findings (1987, cf. 5.7), as the novices may not have had a structure of existing information in which to include the new information, whereas the experts had. The novices did not have much material to rehearse or match with, nor have any reason to want to remember it. The experts, on the other hand, may have had all these structures already in place and been able to augment them. The experts used additional information for factual storage but also for augmenting patterns or ways of working. The better recall by the experts implied they had better ways of working, more satisfactory means of recording the information and probably already had permanent structures in which to place and remember new information. Some users were despondent and apologetic about their recall while others were unconcerned. The nature of recall also had an effect as those users with more graphic or representational recall methods; they remembered better, as on the whole did the experts. Some users, again mostly experts, had excellent recall and remembered each specific task; they were classified into the good recall group. This area may reveal a confounding issue, as this would be the case if the experts already knew the subject area or the package, but would they be more highly motivated if they did not. The answer to this may be that they were very used to using multimedia and very confident in their ability to do this and so appeared less reticent and more willing to do the multimedia research. Another point here is that the experts were in their chosen professional area and so to an extent had already self selected themselves. As this was their job, and their job functions included investigation/ analysis of multimedia, they would inevitably value researching these areas and have greater motivation.

18.12 User issues - Individual perspectives in the empirical work

Research cited by Plowman et al. (1999) on the use of narrative by teachers is relevant to this thesis as the research takes into account factors such as the individuality of users, the social context, artefacts and the environment. Plowman et al. proposed that narrative guidance and narrative construction are interdependent. Their findings supported the view that improved multimedia design and awareness of this interdependence would lead to benefits for the users. My research found that structure is essential for the novice, and to a lesser extent, intermediate users. It is only at the expert stage that users are capable of, and sufficiently confident; to construct their own working/studying environments and therefore have less need for designers to build structures into the resource. In the multimedia sessions, some of the experts were very critical of the structure and some of the contents of the multimedia resource and criticised it, commenting that they would not have created it like this or querying why more information or different search engines had not also been included with the basic ones available. Research on learner control, such as Nelson's work (1987), found that skilled learners choose more options, which was certainly the case in this empirical work.

Goetzfried and Hannafin's (1985) findings that skilled learners learnt equally well or better under their own control, while less skilled learners made poorer choices about sequence and chose fewer options, were also true for the users in this research. However their claim that they performed better under program control has not been shown here, as the users tended to perform less well in the more structured Task Two, unless they liked the subject. In the other tasks the skilled users certainly chose more options and made better sequential choices. However Steinberg (1989) found that when users were allowed to control the sequence of instruction on, or off the computer, they learnt less well under program control, unless they were already skillful in the subject. These results contradict those from this research, as the experts preferred less control and worked better under their own control, while the novices needed program control, at least initially.

Hannafin (1984) stated that it was the type of lesson that causes a difference in the type of control that was better for learning/working. In my research the tasks allowed more user control in the first browsing task and in the third open task, but restricted the options in the second set task. This allowed for the effect of user control to be analysed and for comments by the users on which of these two styles (with or without user control) they preferred. On the whole, in both the first and the second study browsing tasks the novice users were more hesitant. Some users stated that they would have preferred a more ordered task, in other words more program control. Some users found the browsing task very valuable as an orientation tool and as an introduction, while others were unsure where to start. Many expert users began this first task straight away, and were happy to explore, indicating the expert's confidence and their ability to have their own control over the navigation within the package, while the novices found this degree of freedom difficult. In the second task some users exerted user control by not following the specific route. This was a result of the content, i.e. heavy text based material, rather than the task itself, while others followed the prescribed route. In the third task the novices were again more reluctant to start this, and the older group of children, in particular, preferred a set task and asked for a more specific (defined) task.

From my research the novice users preferred more program control, but the experts disliked being too controlled and were prepared, and able, to leave the set instruction plan if they found it boring or unproductive. In the same way the experts were quicker to both evaluate paths and to change or adapt them if they proved unsuccessful, while the novices could not, or would not, do this. Conversely, and perhaps rather surprisingly, the novice children, especially the middle group (7/8 year olds), preferred choosing their own paths and disliked being given topics to research. However the older first study pairs thought that the third task was time wasting and wanted a very specific and defined task rather than the more open layout task. Hypothesis 2, that certain navigational patterns are more successful for the user than others, can be supported, as the novices preferred patterns that controlled how they navigated through the package and that supported their journey through the resource. A structured pattern with a linear or sequential theme would be most successful, or possibly even a hierarchical pattern for more specific tasks and searches. The experts on the other hand wanted to have tolls and controls available to them and therefore needed the ability to use complex navigational patterns. These findings support the broader research questions (1.9), the first part of Hypothesis 2 and to a certain extent the second part of hypothesis 2 (that patterns can be reused), but the proposal that patterns of more experienced users can be taught to less experienced users, was only partially supported. The hypotheses are detailed below.

18.13 User issues - Individual preferences

The individual perspective can be demonstrated in the individual routes (Charts 15.1-20, in Appendix 3), which plot each individual's path through the software. It is noteworthy in these charts that although there are similarities in their patterns, there are significant differences, even when the users were meant to follow the same route (as in Task 2). The preferences in the ways they navigated and worked through the resource, demonstrate each user's individual approach.

Each of these individual approaches was different and it would have been difficult to persuade all users to use the same resource in the same way. However in an educational package, with specific educational objectives, it may be equally difficult and not make sense pedagogically, to allow everyone to follow totally different routes. However some routes or sections of routes were common, e.g. certain subjects and links were of interest to many users, while other areas were rarely or never used.

This information on commonly used routes and missed sections is particularly effective in a conventional teaching situation; as if users missed essential sections this may be detrimental to their understanding. Similarly if there were areas of common interest these could be used to good motivational effect and areas of little interest removed or improved. Horney and Anderson-Inman's (1994) results supported this finding as they found that changing the software affected user's interaction with it, whilst improving the comprehension exercises in the software meant that more users used them. The recognition of the individual patterns is crucial to the individual's progress, as it is well known that individuals study and work best when they are well motivated and not bored. The level of teaching and understanding has to be commensurate with their present or their next/ aspiring level. These individual preferences are vital to the designer of the resource as well as the facilitator making use of IT, as knowing the preferences users have, would allow designers to build in a range of suitable preference decisions or options.

18.14 Discussion of the hypotheses for the research

Four hypotheses were developed in the methodology chapter (cf. 4.19) and these are now discussed in conjunction with the empirical work results.

The first hypothesis was **'That each individual has preferred methods of using multimedia'.** This hypothesis was supported, as all the participants had preferred navigational patterns and working strategies. The empirical work for the first study revealed some use of navigational patterns and these were classified. All the children had some preferences in the way they used multimedia, although these were not as set as for the adults. The adults had very distinct preferences, most using some form of linear and hierarchical methods. More experienced users combined search methods into the complex patterns, which was not done by first study children.

The second hypothesis, **'That certain navigational patterns are more successful for the user than others'** was also supported. However it has proved difficult to quantify this hypothesis in terms of how much more successful certain patterns were than others. There were broad indications that certain types of patterns were more effective than others. These effective patterns result in a more rapid assessment of where the required information is, and more satisfactory ways of getting at it, hence these patterns were more beneficial to the user. The selection of certain navigation patterns improved the movement through the resource, and resulted in quicker and more thorough material collection.

Some of the navigational patterns proved to be very slow and not very conducive to finding the most information on a specific topic. This was particularly noticeable in the first study, where the software packages usually required a mixture of different navigational patterns to fully explore their content. The expert users, who selected the widest range of navigational patterns and worked more quickly than novice adults, were the most successful in terms of their information retrieval.

The second part of the second hypothesis **'That these patterns can be re-used and more experienced users patterns can be taught to less experienced users,'** has only been partially supported. These users employed navigational patterns in the third task, which closely followed the examples they had used in the second task. Some users were very careful about this and changed their method of using the software from the first task to the third, using methods that they had initially tried out in Task Two. There were several examples of this, where a user followed the enforced pattern from the second task into the third task, which was different from their navigation patterns for the first task. In these cases the users benefited and gained more control and confidence in using the package. The ability to teach the use of beneficial navigation patterns was explored, as examples were found of reusing the same patterns. However there was insufficient evidence to fully support the hypothesis.

The first study children, even very young pairs, were prepared to follow instructions or alternative routes if necessary. In a few cases in the older children's groups, e.g. when using Medieval Realms, when they came to the end of a search or did not find what they wanted, they asked for help in rerouting their search, which then enabled them to complete it. The second part of the hypothesis that patterns of more experienced users can be taught to novice users was not fully explored in this research. Although it was found to be beneficial, especially to the novices, when they were taught to use more successful techniques (e.g. in second task). There are problems with teaching novices' skills which have been developed by experts over a long period of time. However the more rapid techniques, and the stop and restart abilities if the search is unsuccessful, are techniques of immediate benefit to novices.

The third hypothesis **'That navigation patterns can encourage in-depth searching and potentially deeper working'** was supported as the complex patterns showed some deep searching and the links the users created in the resource. Their comments on the use of the software indicated that some deeper working has been done. The hierarchical and complex patterns appeared to encourage deeper patterns of navigation than the linear, circular or star patterns, as the searches were carried out to greater depth in the resource.

It was significant to note that most users, except for the younger and middle groups of children, did use both linear and hierarchical patterns, although they were at different times. Again the expert users were the ones who explored to greater depth, developed their subjects and links within these subjects, more successfully than the other groups.

Certainly the opposite of this hypothesis, that certain patterns encouraged surface working, did occur in a few instances, as some of the simpler navigational patterns, (e.g. linear), encouraged working at a similar and superficial level.

The fourth hypothesis, **'That experience of multimedia or controlled use can enhance the usage of multimedia'** was supported, as the users improved through the session. The experts, who had much greater experience of multimedia than the novices, considered that they had improved their own way of working through the multimedia package, and improved more in relative terms than the novices. The expert's use of multimedia was often very controlled. Their experience from using other software made these users much quicker at changing their route or trying another area, than those with less experience. Hence all the hypotheses that were fully explored in the research (Hypotheses One, Three and Four) were supported.

However Hypothesis Two, although it had some supporting evidence, had less specific evidence available and this hypothesis would benefit from further investigation.

18.15 Conclusions

From the evidence of the empirical work the users initially adopted a surface approach, i.e. starting with an overview or introductory approach to the software. However it was also clear that not all users were able to develop this into a deep approach. The experts were frequently able to do this and tended to use a range of methods, both in terms of their navigation and in their working strategies. This range gave them variety and allowed them to develop their own understanding of the material they found in the resource. The novices though, rarely exhibited deep processing, although there was in-depth searching. Relatively few of novices managed to relate their new knowledge to the information they already had, and few novices made further connections or developments with this prior knowledge or built their own knowledge structures.

The main findings of this thesis are that each user had their own individual preferences on how they navigated and worked through software. If users are to be encouraged to construct their own study environments then they must be encouraged to develop their own skills in directing their use of educational software. They also need to become aware of methods of developing their own skills and abilities. If motivation is increased and users can select their own options, this encourages a deep approach. Further research is needed in this area with more participants, but even with the present evidence navigational pattern facilities in multimedia extend each individual's potential. Multimedia designers can enhance navigation features and can provide users with individual help, and given to them, in terms of instruction and in content, in the methods they prefer and in the manner in where they will gain the most benefit.

19

Implications for practice

19.1 Introduction

My research has shown that the individual's choice of navigational routes is crucial to the way they use multimedia. Trumbull, Gay and Mazur (1992) came to similar conclusions, and stated:

> Crucial questions raised by these data concern the way users can be alerted to the amount of information in a hypermedia system, the significance of users predispositions and characteristics that affect their tendencies to choose different search modes, and the means to help users develop systematic ways to use the system (p327).

Parunak (1989) believed the way users navigate relates to how they normally operate:

> The problem of navigation in hyperspace can be addressed by considering the navigational strategies that people apply in the physical world (p49).

Both these quotes state that users have preferential ways of using software, but also imply users employed different factors in their selection of navigational routes. There are broad relationships between certain types of navigational pattern, for instance the majority of users used both a linear and a hierarchical pattern. However there were more evident links between different groups of users based on their skills and abilities. This chapter starts by looking at the contribution this research has made to the subject area. Specific outcomes from the research are then analysed in the two main areas of navigational patterns and working strategies. The implications for designers are reviewed and potential software improvements are included. Finally future research ideas, and areas worthy of more investigation, are developed.

19.2 Guidelines for users and designers

Research by Bernstein, Joyce and Levine (1992) looked at hypertext readers recognising when users returned to places they had already visited. This contrasts with Rouet's (1992) argument as he assumed that user's revisiting a node was evidence of their disorientation. Bernstein et al. believed that repetitions help modulate the story, and may even allow 'multivalent passages', where the meaning has changed due to new understanding. They felt that linear reading was a passive activity while hypertext encouraged the user to select one path or another, to pursue one goal and avoid a different one, and stated that:

> Secondary navigational modes (bookmarks, history menus, navigational undo, breadcrumbs, search and link-creation by readers) transform almost any hypertext into a single strongly connected component (p.167).

Developing the use of link creation techniques by the users, the techniques of mind mapping or other mind tools could also be applied to multimedia resources with an open resource format. These resources could be adaptable by the individual user. This multimedia could have a simple structure or basic level navigational system, help files and teaching resources for the novice or inexperienced user, while allowing the experienced user time to develop their own system with the existing material. This could in turn involve using mind maps to create a structure for the material or using various tools to interrogate the database or to develop their own particular themes. The resource could be a starting point for their own work/ project development possibly augmented with their own material and allowing them to structure their own resource bank. The methods for creating this resource bank, as well as teaching the users the necessary abilities to develop and use mind tools in order to adapt the resource, are issues that need further research. These affect not only the teacher but also the multimedia developer. Hence although the concept of allowing users access to multimedia as a resource is a constructive one in practice, it necessitates a great deal of careful design work. As there is substantial investment by the teacher and the user in mind tools, these developments should not be undertaken lightly or for less suitable subjects or basic courses.

The issue of obtaining feedback from users is a difficult one as several multimedia designers, who were interviewed, had little or no contact or feedback for the multimedia they had developed. The experience of the designers based at the Open University (several of whom were participants in the multimedia sessions), who have a great deal of feedback and many iterations of software, is not representative of commercial designers who have less contact with their users. The software development benefits from expert user's feedback as well as novices. An exception to the commercial development scenario with little feedback is the development regime created by the British Library for the production of the Medieval Realms software, which included pupil, teacher and specialist user trials. This should be encouraged as an example of best practice in multimedia development.

19.3 The user perspective – Implications for users

This thesis has used the previous research work of Horney (1993) and Canter, Rivers and Storrs (1985) in determining navigational preferences, however these were relatively small studies and they did not produce any recommendations for future software design. This thesis contains a substantial first study on children and a second study looking at twenty adults in depth, producing detailed individual patterns that have developed the concept of individual patterns preferences. This navigational patterns research has shown that each individual has preferred methods of both patterns of navigating and strategies for working through multimedia. It has been possible to group these users, in terms of their experience and abilities, in broad novice to expert categories. The implication is that software should be designed in order that the user can navigate through it with their preferred patterns. It has also been shown that there may be benefits in subdividing these groups and that it is possible, even with a small group of users, to assess those that are in an intermediate stage between novices and experts.

The research has shown the amount of control and self-determination that each user wants, and how this changes over time and through experience. Building up a dossier of these skills and techniques already being used, and linking these into an expert system which can inform the user of the most suitable way of progressing, may begin to use highly interactive software in a more educationally demanding, but also more beneficial way than it has been used to date. Concentrating on the individual customization of each resource for specific users should improve the learning and the time spent in the software, and begins to question, but in some ways answer, the pedagogic perspective of educational multimedia.

Looking at the contributions to the research four areas relate specifically to the user:

1. The individual user's preferences in navigating multimedia resources
2. A method of recording each individual's navigational routes
3. Individual and comparative analyses of the user's navigational routes
4. Information on how specific multimedia packages are being used by individuals

Users should be aware of their own preferences for both navigating and working. It is possible for an assessment method to be set up to allow users to assess how they prefer to use multimedia (based on the methods used in this research). Allowing use of preferred methods with tutoring in this preference based multimedia, would improve user centredness of the design process.

19.4 The designer perspective – Implications for designers

The key areas of this research in terms of implications for designers are threefold. Firstly we need to develop several different approaches or access routes to the same resource material. Secondly we need to develop multiple ways of assessing the material, to cater for its variety and cognitive potential. Thirdly we need to cater for individual preference and ability: in terms of how we use it and how or what we learn or develop from it, realising the value of experience. In fact from educationally stimulating and innovative multimedia the learning outcomes may be different for individual users, even within the same complex multimedia package. The implications for designers include the benefits and the application (by the user) of structural components such as: design aspects, navigational tools (e.g. maps, sub-menus, help, tutorials, history, customobility features) interfaces used; and the known and possible navigation methods. There are new navigation tools that designers are now beginning to implement, such as landmarks, beacons, breadcrumbs, searchlights, antennae, sensors and memoranda, which have been used in various contexts but rarely as a library of tools that every user could have access to. Indeed there could be user preferences in the type of navigational tool they prefer to use. Norman (1994) has also argued for a list of items, which should guide the design of hypermedia systems. Norman has proposed: using such guides as spatial metaphors, indexes, navigational tools and allowing feedback and reflection. Gay and Mazur (1991) argued for visual organisers, maps and both indexes and online guidance and help. A similar list could be created for multimedia systems. Examples from the literature review are: Parunak who created a basic list of topologies and Trumbull et al. (1992) who looked at the range of tools employed. These researchers have proved a valuable precursor to the detailed navigational patterns' and working strategies' classification.

19.5 The pedagogic perspective

The pedagogic perspective has been addressed in this thesis. The first two perspectives – user and designer, were selected and dealt with in more depth than the last two perspectives, as it was felt that it would be necessary to develop these first before further work could be done on developing the pedagogic and HCI perspectives. The fact that each individual has been found to have preferences for navigation and working strategies is significant. Designers will have to create multimedia for the educational market that incorporates these preferences. Additionally the work on the intelligent tutor (outlined later in this chapter) has come out of the designer work and this would have real pedagogic advantages if multimedia designers started to use these design elements in software development. One pedagogic principle that was followed up was the importance of the individual and the ability to create multimedia for each individual. Using the design work from this thesis should allow more accurate development of individual specific or adaptable software.

19.6 The HCI perspective

The HCI perspective relates to how the user views the computer software and the relationship between the user's views and those of the designer. In order to fully comprehend this it was considered necessary to fully develop the user and designer perspectives and then there would be empirical data on which to assess the HCI perspective, and this should be developed further in future research. The fact that individuals have distinct preferences and that few multimedia packages allow the user to select their own navigation preferences is significant and supports further exploration of the HCI perspective. Relating back to the introduction, if designers are to overcome Conklin's (1987) well known 'lost in space' dilemma they must provide sufficient identifying points for the user to know where they are. If Landow's (1990) concept, of using hypermedia as being similar to navigating a ship through the sea, is a relevant and usable analogy, then designers have to provide proper navigating tools such as maps or charts, tools and some indicator of where the user is within the package i.e. some form of state map. Landow considered it was impossible to create a spatial world in hypermedia and so it would be impossible to create this environment. However as multimedia is often seen and can be constructed, as a spatial world, then it would be possible to create these navigational maps and tools. The need to develop helpful, informed navigation through this multimedia spatial world has been an underlying theme in the thesis and the multimedia components discussed later would create a navigational shell.

19.7 Working strategies

This thesis has investigated the differences between the user's navigation and how they prefer to work. The working strategies as well as the navigational patterns have produced information on individuals but also some use of specific strategies by groups. The literature review outlined Trumbull, Gay and Mazur's research (1992) on the techniques and strategies employed, and

Brooks, Simitus and O'Neil's (1985) work, which proposed four categories of individual differences, which were related to working strategies. This research has produced evidence of distinct preferences in the choice of working strategies, some of which have links to the navigational patterns used. Most of the users selected some form of sequential method going through the resource. The rapid clicking, orientation pattern was particularly liked by young children, but most users employed some form of researching methods. Complex or composite strategies for working methods were concentrated in the expert group, but each group covered a wide range. Users of more complicated working strategies used complex navigational patterns, and less sophisticated navigational patterns users used simple working strategies.

19.8 Intelligent tutor concept

The research reported in this thesis has looked at differences between children and adults and novices and experts. However the range within these groups is also wide and it is significant that the main element of most of these research projects is that each user is an individual. It is possible to classify these individuals into types but it is often the individual differences that are the most significant. This then moves more into the area of producing multimedia, which can be adapted for each individual. These proposals begin to move in the direction of the Intelligent Tutor concept. This is an underlying set of programs, which would create an expert system type application, linked into the main multimedia package. This could record the user's use of the package, their preferred navigational paths and working styles. It could give practical, context relevant help, which would also be linked into their level and ability as well as the factors above. The program could then suggest the best or list of optimal routes to find certain information even giving the amount of time needed for certain search types or routes. Mischanuk and Schwier's work (1992, cf. 3.8) outlined this area when they suggested that audit trails helped users by giving them an indication of routes past users found helpful, or by simply suggesting suitable routes. This could be expanded into a tutor companion role where the software monitors where the user is going, through the history function, but relates this to other successful searches by other users.

It could link navigation help into the user's preferences or task. The teacher could suggest optimal routes or alternative methods of reaching the goal in the most economical or appropriate routes. Following on from Romiszowski's (1993) arguments, there are substantial reasons why the intelligent tutor approach should be exploited. As Romiszowski (1993) argued there are four types of interaction between a computer and a human 1) Instructor to student, 2) Instructor corrects and gives examples, 3) Conversation that is student led, e.g. questions arising from hypermedia and 4) Instructor takes student beyond original question such as in an intelligent tutoring system. This then suggests that intelligent tutoring systems are required for good multimedia. The best route approach may overcome problems of the user becoming lost or disorientated or sidetracked and help to get them rapidly back on course. Using multimedia in a classroom may create problems, as the time available for each group is resource dependent and so restricted. Encouragement of free learning or browsing is time consuming. This may have to be tempered with more controlled or ordered software use for practical and pedagogic reasons. This moves towards the use of intelligent tutoring systems. Specific requirements for an educational multimedia system are outlined below.

19.9 Beneficial features for quality multimedia

Features that benefit multimedia and that are the component parts of good quality multimedia:

1. Navigational tool Diagrams or Map
2. Prior Knowledge/ Known material
3. History
4. Audit Trails - navigational paths used
5. Time line
6. Activities - Worksheet/ Tasks
7. Index
8. User levels
9. Internet links
10. Individual student records/personal histories - User usage
11. Customobility issues
12. Curriculum/research links
13. Off-line facilities
14. Expert guide, introduction/ introductory tour, tutorial
15. Intelligent Tutor

1. Navigational tools, diagrams or maps

This would give an indication of where the user is in the package, of how much is completed/ visited, how much is left and where to go next, and a list of ideas. All of these could be placed in a special navigation window or as a plan/ map available to the user as an additional tool. Additional tools that could be offered to the user include landmarks, beacons, breadcrumbs, searchlights, antennae, sensors, memoranda and tour guides.

2. Prior knowledge/ known material

Information that is already familiar to the user (prior knowledge) should be included in the resource. This could be based on course or year work in order to create a starting point, or based on key/ core areas. Users need to affirm prior knowledge to assess the reliability of new information.

3. History

A history of the choices made, such as where the user had been in the package or even of alternative routes not initially followed, could be included, as well as where the user is now. This would give the user some idea of their development or progress, and it could be linked to tasks to produce a record, either of the individual or of the group. This would enable the users to restart where they left off, enable them to save their own research and to be aware of their own progress. The preferred choices could also feed into staff/ tutor information and into the user's own performance files. Another awareness issue is how much of the resource has been covered or dealt with, and how much left. This information would be beneficial to users and is also supported by results from my empirical work. Users, especially children, were very inaccurate with assessing how much of the multimedia they had visited, often overrating their own abilities and believing they have seen most of the information, even when only using the package for a small time. Users often wanted to know how much they had covered and how much there was left, not necessarily of the resource but more essentially of the associated tasks. This specific area is one where the book metaphor products have attempted to cover in a visual manner. The screen book gives an indication of where the user is in the book such as the chapter or page and how much they have covered as well as how much is left. This feature could be made more sophisticated and link to teaching or pedagogic areas, showing potentially relevant areas and how many of these have been visited.

4. Audit Trails - navigational paths used

There may be some benefits in allowing users to see their own audit trails or navigational routes. These may show them how they are performing in relation to their progress through the package. A graphical representation of these trails could show them the best route or other methods of accessing the information. The link between audit trails and the history of where the user has been is significant, as is the idea of the transparency of paths or an awareness of route by the user. Some indication of the nature and extent of choices or options to be made, and their relevance to the task or work, as well as relations between them, is valuable. One way this could be done may be to set up a facility of a keyword or thematic search to link areas of most relevance to the user. The user could then extend or reduce this; the software could then be developed to produce a best-fit path to enable the user to go through the resource in the most advantageous way. This is overlapping the concept of both an intelligent tutor and mind mapping, but is possible within most multimedia.

5. Timeline

A timeline is a historical or linear setting that gives the user a way to approach the resource. The Timeline gives a sequence, which allows linking of knowledge in time, or to a date or event, and it may provide anchor points for users. Certain users have a marked preference for linear multimedia.

6. Activities - Worksheet/ tasks

An activities section would be able to cater for different ability levels. It could range from a series of outline topics or list of ideas to full activities and worksheets. These would be achievable within the particular multimedia package and could also be linked to level or abilities. A record of the progress of work could be kept. The worksheets themselves could be arranged in increasing order of difficulty, the teacher or user could adapt them, and they could be integrated into an assessment programme. Information such as the time taken, which sections have been completed and the level of attainment could be included. The degree of assessment or complexity may relate to the subject content or to the level at which the software is aimed. Group work could be given some form of assessment, and problematic areas, such as the amount of input by each user ascertained.

7. Index

The index could be linked to the place or position in the package where the user is, hence being a context sensitive device, as well as a conventional list. Essential aspects regarding the index are: easy access, a glossary of terms, a basic alphabetical index, names /places index, and a thematic index. Information on understanding the subject e.g. difficult concepts covered, could be included.

8. User levels

The user levels within the package could relate to ability level or age/ year group. This could record achievements, where the user has reached, perhaps linked to a personal file, and a user/ tutor file as well as comments on access, where to start, how to use the levels, teacher's notes on where to start, any comments, future improvements or modifications and any innovative ideas.

9. Individual student records/ personal histories, student/user usage

One function of the intelligent tutor software could be to monitor user usage patterns. It could also keep a record of each individual user with information on how they are progressing, as well as which paths they took. This could be analysed to determine their preferences, and to enable links to be made, with suggestions or help facilities to these preferences. It could keep records of where the user gets to in the package so that they could pick up the search where they left off. This would be valuable when several users are attempting to use the same resource. It could register the amount of work done, which exercises have been completed and the amount still to be completed and allow the tutor to see which users need more computer time and who has completed sufficient or more. These are features that many teachers do not have the time or the resources to do manually.

10. Customobility issues

The degree of customobility within the software package needs careful consideration. This could range from basic features (e.g. cut and paste) to complex ones, ranging from introducing new material, to creating presentations and developing their own projects, to rearranging the whole resource. It could be user or teacher based e.g. selective use of the resource for a particular project or their own tour. Other issues such as off task or off computer time could be included. Facilities for teachers to add their own notes, worksheets or project outlines could be included, as well as ideas for group work/ task allocation.

11. Curriculum/ research links

The package could be specifically linked into research topics, or topics that are capable of being researched in the resource, and complementary teaching materials could be included in the package. These would be separate from the main resource to allow easy updating and customising. They could include: planned activities, worksheets, signposts/ help on topics, user level, how to use multimedia, using specific packages - scope, number/ time of visits, and suitable age group/ subject. Teachers could spend time researching and helping user's rather than creating resources.

12. Off-line facilities

Another area difficult for users of multimedia is the time consuming tasks, which can stop current work on the computer. These basic tasks such as printing, file saving and backup could be performed while the user is off line. This is especially true of printing, as printing could be set to print after usage, again linked into the monitoring program, which could list the requests and do these when the machine is no longer required. This is especially relevant where there is no background printing e.g. Grolier's, or in rooms where physical (actual) noise is a problem.

13. Internet links

Some of the multimedia packages are now including Internet links that give the references to relevant pages on the Internet. This is a helpful service provided these addresses are kept up to date. The Internet links could be used to extend the scope of certain packages and allow users to develop their own project work and personalise their searches. This may encourage naive users to continue searching for material without any fixed purpose, or to think themselves working when they are searching randomly or off task. Some control element would enable users to extend the scope, to find out more, allow access to different material, such as up-to-date information, multimedia material (such as video, speech etc.) and to search internationally if relevant.

14. Expert guide, induction/ introductory tutorial or tour

Users also need training in how to use the system, especially how best to use it for specific types of task. Users have preferred ways of using multimedia and will use these even if they are not very suitable. It is necessary, not only to make it easier for users to use their preferred strategies, but also to provide guidance. Sophisticated help or expert systems could also inform the user of alternative or more effective methods of using the software. This may be especially valuable for novices or where learning is essential, such as prescribed course software for an academic course.

15. Intelligent tutor

The last feature that is recommended for use in multimedia software is the intelligent tutor. This has been detailed above in Sections 19.5 and 19.8, and the component elements are detailed in 19.11 (overleaf). The development of this type of facility would greatly improve educational multimedia.

19.10 Conclusions

Horney whose work has been used extensively in this thesis to provide a core navigational research background, stated, when referring to his navigational patterns in relation to hypermedia which are here as applicable to multimedia:

> If such patterns represent authors' (users) natural navigation tendencies, then future hypertext editing systems should allow users to transcend the limitations of even non-linear data structures (p.269).

This promotes the view that the development of user preferred navigation patterns would allow users to progress beyond the usual constraints of hypermedia/ multimedia and to be able to understand and use these additional facilities.

Fig. 19.11 Checklist for the Intelligent tutor system requirements

	Checklist
History	• Each user, Where been, where left off, exact sites/ nodes visited • Relate to groups • Work completed, Grades • Hierarchy/ significance levels
Navigational Routes	• Preferred methods, introduction, suitable modules • Best route, amalgamation of others routes, tutor's route • Perceived best route • Links where to go next • Most successful method • Previously used methods • Possible options
Tutor/ teacher	• Record of user achievement • Each user's route, most popular statistics • Links to most successful • Previous use of computers/ multimedia • Completed work/ grade • User level - where start/ progression
Learning system	• Assessment of user preferred working methods/ styles • Problem areas/ redundant/ unused sections • Tasks - ability levels • Where to go next • Complexity levels, higher ability/ basic level
Individual	• Difficult to understand/ too easy • Portfolio/ knowledge of routes/ Problems • Specialised knowledge of own preferences • Areas that need repeating/ Strengthening additional exercises • Extending/ higher exercises • Ways of extending/ improving coursework
Issues	• Pointers to ways of improving/ gaining better assessments • Node/ Screen identification • Classification of paths • Problem of dead ends • History information/ separate resource • Links between users • Security - across user body, confidentiality

20

Thesis evaluation and implications for users

20.1 Introduction to the evaluation

The first part of the thesis evaluation covers the thesis achievements, significant contributions to research and the future research potential of this type of in-depth individual investigations, and of navigation research in general. It forms part of the thesis conclusions and a necessary part of the assessment of any research project. The second part looks at the research that has been undertaken in this thesis and investigates the user implications and the areas that require or would benefit from future research. Future research areas would be to include more users, an obvious starting point, to gain an understanding of how appropriate analysing navigation patterns is for larger populations.

20.2 Synopsis of the main findings of this thesis

There are five main areas that been discussed in this thesis. These areas will be further analysed below and in the outlines for future research that can benefit designers and users of multimedia:

1. Navigational patterns
2. Working strategies
3. Differences, and the relationship between navigation patterns and working strategies.
4. Differences between the groups, a) Children and Adults b) Novices and Experts
5. Individual Perspectives

20.3 Achievements of the thesis – this thesis's contribution

Previous research has examined navigational patterns, however relatively little research has been done on a systematic classification of patterns followed by empirical investigation, and comparatively little research has been done on methods of working, employed in relation to navigational patterns. Future educational multimedia design should take advantage of this type of research, so that the navigation methods and the user benefits, become core elements of software design. The research has shown that each user has distinct sets of navigational patterns and employed preferred strategies (Hypothesis 1). Researchers have considered it significant to differentiate between navigation patterns and working strategies, and although there are variations in how this is done, this dichotomy was critical in this research, as users demonstrated a relationship between the navigational patterns and the working strategies. The range was wide with some users being restrictive and using a limited range, e.g. linear patterns, while others employed a full range of the available patterns and strategies.

Hypotheses for this research are as follows:

Hypothesis 1 -That each individual has preferred methods of using multimedia
Hypothesis 2 -That certain navigational patterns are more successful for the user than others, that these can be re-used and more experienced users patterns can be taught to less experienced users
Hypothesis 3 -That navigation patterns can encourage in-depth searching & potentially deeper working
Hypothesis 4 -That experience of multimedia or controlled use can enhance the usage of multimedia

Hypothesis 2 is the one hypothesis that has only been partially supported and needs further examination, and is a key starting point for further research in this area, as Hypothesis 2 had some evidence to support it, but insufficient to fully prove it. Multimedia and design considerations for each audience (i.e. children and adults) should be considered in the light of these findings. The research has shown that there are distinct differences in how novices, intermediates and experts use software and consideration of these different needs should be built into software. Deep and surface investigations can be performed in large resource multimedia but these techniques need to be first shown to, and developed by, the users themselves (Hypotheses 3 & 4). Individual perspectives are significant and software design should incorporate navigation and working preferences (Hypotheses 1 & 2).

The key finding of this research relates to the main research question: Do individuals have distinct preferences for certain types of navigational patterns? It was found that the actual navigational patterns that users employ are recognisable and classifiable. If software designers can recognise how users prefer to work, then the educational material can be designed so that it is easier to use and more attuned to the individual user. Additionally if the users normal method of using software is restrictive or not the most beneficial method of approaching the subject, the software package design can encourage more successful methods of working. In the empirical work many users returned to methods they originally used in the first task, for the second or third tasks. If a new method of using the package was introduced many users then re-used the technique in subsequent tasks. Finally Barab et al.'s (1996) request that future research should compare navigational paths of various groups of individuals was fulfilled by this research.

20.4 Significant contributions to research

The analysis of the empirical studies was intended to produce the following:

1. An investigation of individual users' preferences in navigating multimedia resources
2. A classification system for navigational patterns
3. A method of screen by screen timed recordings of user's progression through multimedia
4. A method of recording each individual's navigational routes by using charts
5. Individual and comparative analyses of the user's navigational routes

6. A method of recognising, describing and classifying working strategies
7. Information on the usage of multimedia by individuals and by two specific groups: 1) adults/ children, and 2) novices/ experts
8. Designer guidelines for navigational tools and techniques promoting the individual for multimedia design
9. Topologies of the multimedia packages
10. Methods of using each package's topology to link these with the navigational patterns
11. Reporting the results of an expert's panel review of the navigational pattern classification and its verification as a workable series.

It is a significant achievement of this thesis that all these factors were included in the research and all of them were satisfactorily completed. The method of analysing the user's individual routes through software could be applied to other multimedia and used to analyse the navigation methods. It could demonstrate which sections of the package are used and which are not visited. Recording these routes automatically and superimposing them or analysing them electronically could allow this technique to be used for many users, or possibly all users of the package. Most multimedia packages have distinct nodes within them and these could be analysed for the number of visits and the time used. Designers should use the individual user's navigation and working preferences to develop the most preferred and beneficial navigation patterns into new multimedia. Users could be made aware of their own preferences and how these can be used to access and progress through a specific multimedia package.

20.5 Limitations of this thesis

There are some limitations or criticisms of this research. It was found very difficult to quantify learning from the multimedia packages and this aspect of the original research proposal was removed from the research at an early stage. This may have been because the previous knowledge of each user was crucial in relation to what they searched for, and their skills and abilities in doing this affected the amount and nature of the material collected. It may have been informative to investigate more than one software package in the Second Study, to see if the same patterns occurred, and to see if techniques learnt in one package could be transferred to another in a different context. The initial research proposal included case studies, e.g. where users would go through all four specific paths and comment on them, but due to the time involved and the larger first study, it was decided not to do these.

The multimedia package that was used for the second study, Encarta, also had Internet links. However due to the slow response of the computer(s) used for the multimedia sessions, I decided that waiting for links would take up disproportionate amounts of time on the search. The Internet links were not made available, although incidents where users wanted or requested that they would like to have tried the Internet links were recorded. Allowing Internet exploration would have allowed further development of their searches and may have affected their navigation patterns.

There is also a problem with the number of users feasible within the time scale. The first study was quite large and as the second study was based on individuals it meant that fewer users could be tested than in the first study. More users would be needed to determine if everyone has preferred patterns of navigation and working strategies and also to determine if there are more definite groups or selection processes within these. Further users may allow refinement of the patterns, especially the complex ones and to extend links between the preferred patterns of navigation and working strategies.

20.6 Future research development of the researcher

The researcher has undertaken observations both manually, and by computer of a range of users from primary school children to experienced multimedia developers. The research has involved liaising with and setting up the sessions with different equipment and within set time frames. The recording methods for the interviews and note taking as well as the semi-structured nature of the interviews have required research preparation. The research has necessitated the development of various models of user behaviour and an analysis of the best methods of developing navigation within interactive software. All these aspects and skills, which have been developed during the progress of the doctoral research, should allow future research to be conducted by the candidate without supervision. Training sessions in research as part of the EPSRC research methods programme were attended at the Open University. Additionally as the candidate has been working in full time research at the same time as completing the doctoral thesis, these skills have already been used in the academic world. The capacity to develop research as an independent researcher, including applying for further funding, and in leading teams of researchers has been tested while working in full time research at a senior level for several years.

20.7 Thesis development over time

This thesis has gone through a series of developments and changes of direction over time. The first one of these was the change to adults in the second study, the research direction has also changed as outlined in the preface and has become much more human computer oriented than initially proposed. This reflects both changing views of the field over time and my work, as working fulltime in computer science has changed the aspects I was interested in away from educational technology and pedagogy and more towards the designer and user issues. The thesis has also evolved in its structure and component parts. After completing the analysis on the first and second study various additional work was done. This included revisiting the original scanned records of the observation sessions and going through the notes, especially of Task 2, and more work on the working strategies. The topologies of the multimedia packages were also completed at this stage.

Further work on the topologies meant that the navigation patterns could be matched over the structure of the navigation patterns. It would be possible to create a multimedia package that would record each of the resource items as nodes and could track individual users navigation through the package. The need to formalise the navigation patterns also became apparent and the formalisation of each of the navigation patterns was worked through. This formalisation has proved to be very valuable to the thesis and to future research as no other researcher has done this. The information from the other researcher (and this was agreed by the expert panel) is not explicit enough to allow full formalisation of their patterns. The formalisation is therefore very important for future development of the navigational patterns work.

The additional work on the thesis also moved the thesis further from Gherardi and Turner's (1987, cf. 7.3.1) view of the use of discovery rather than verification work. It was considered necessary, after having elicited the navigational patterns from observation, and therefore having followed the discovery route, that this would benefit from a more detailed investigation by experts, of the resultant patterns. This verification process and the results of the expert panel (reported in Chapter 15) served to support the range of navigational patterns and gave an added strength to my classification and also to empirical work of this kind. The additional work has strengthened the original thesis, and further supported the classification of the navigational patterns, consolidated the working strategies work and validated the classification and navigational patterns research.

As the navigational pattern sequence has been strongly validated by the expert panel, and the classification agreed as being more comprehensive than previous researchers as well as reasonably easy to interpret and use, this gives further impetus to both the need and benefits in further navigational patterns research.

20.8 Summary of the thesis evaluation

The conclusions to the thesis evaluation are that it has made a significant and original contribution to the research in the field of navigation patterns. The research has produced a comprehensive classification of both navigation patterns and working strategies, an innovative method for recording individual users navigation through multimedia packages and a way of recording each users use of the multimedia resource by means of graphs. It has promoted the concept of the individual user and the importance of using this perspective by both the designers and the users themselves and moved towards the goal of user centered and user controllable software. The navigation pattern's classification has been verified by an expert panel, comparing the new classification with that of two other researchers. The researcher has developed quantitative and qualitative methods, completed a large literature review, and a multimedia taxonomy.

20.9 Implications for the user and thesis aims

The second part of this chapter investigates the implications for the user and the future research potential for navigational patterns. This starts with an analysis of the thesis aims, outlines guidelines for future research before discussing the problems and drawing conclusions for the whole thesis. The thesis aims from Part 1 have all been achieved. Each aim is listed with a summary of the evidence.

The first aim - To determine a) if users have preferences for navigating in multimedia and b) what these preferences are, was achieved, as it was determined that users did have distinct preferences in navigating in multimedia and these preferences could be established for each individual user.

The second aim - To provide a classification of both navigation patterns and working strategies was successfully completed as a classification for navigation patterns and one for working strategies were produced after the first study and empirically tested in the second study.

The third aim - To ascertain similarities and differences between distinct groups was resolved as each group did have distinct preferential navigation patterns. The fact that some users had attributes for certain tasks which would normally be representative of another group supported the argument that there are no strong dividers between the groups, but that they could be placed along a continuum of evolving and improving skills and abilities. Users that exhibited the more advanced use of certain navigation patterns were further along the continuum than the rest of their group. Each task was analysed separately and then the users were placed in the groups according to the results of all three tasks. The concept of a continuum needs further testing with a larger user base.

The fourth aim - To devise a method of analysing and comparing navigational routes, has been successfully completed, as the navigational charts provide a method of analysing and comparing navigational routes. They also facilitate discussion as they provide a visual chart, which could be used to develop the user's awareness of and development in the use of navigational patterns.

The fifth aim - To empirically test the classifications, has been met as these were developed after the first study and tested in the second. Hence all five of the thesis aims have been achieved.

20.10 Guidelines for future research

The research has revealed areas in the user and designer perspectives that need addressing. These include elements, which should be incorporated into the design, and training aspects for people using multimedia. The training or educational aspects relate to the individual in that they need to be aware of, and develop their own navigational preferences. From the analysis of the hypotheses more work is still needed on one of them (Hypothesis 2). The second part of the hypothesis has been supported with some positive results but needs extensive testing. The development of multimedia design to incorporate the different navigational patterns and working strategies would be an ideal follow-on study for this thesis. It would also allow testing of the various navigational features proposed as future beneficial developments to multimedia in the outcomes of this research. Larger numbers in a user study would ascertain if all users have distinct preferences, what these are, and if certain groups have predictable navigation preferences. This would lead to a better understanding of the designer and user aspects and ultimately better, more user-friendly interactive multimedia. Developing from this research is the necessity to create a list of the areas where multimedia could be improved. This work was begun by Norman (1994) to guide the design of hypermedia systems, who proposed the following:

1) Make use of spatial metaphors
2) Make use of indexes
3) Provide global views
4) Provide homing functions
5) Provide anchor points & landmarks
6) Promote good organisation to reduce navigational demands
7) Provide graceful transitions
8) Provide feedback
9) Allow gathering/ scattering

Gay and Mazur (1991) also believed in having a comprehensive selection of navigational tools. They recommend the following navigational tools:

1) Visual organisers such as global interface or global organiser
2) Maps and other graphic organiser
3) Traditional index
4) On-line guidance and help

Taking these further and developing these into a more comprehensive list means that it is possible to develop the criteria for assessing good quality interactive multimedia. To an extent this brings the research full circle as the initial research starting point was to investigate over 100 multimedia packages (cf.. 7.6) in order to develop an understanding of the present range of multimedia but also to elicit information on the designer and user issues as well as potential navigation patterns. From this the necessary components for good quality multimedia can be created.

20.11 Problems with future research proposals

The proposals for future research do have repercussions on the production of multimedia as these proposed improvements for multimedia are time consuming to produce and could be costly. The additional cost could only be justified by an increase in the benefits of using multimedia and to an extent in very high usage multimedia. The obvious example of this is encyclopaedias. Another area where this sort of online guidance/ tutoring would be useful is in educational multimedia packages, especially where the academic content is of a fairly high level and where there is a necessity to increase the levels of understanding and knowledge through the package. Many of these components could be created as additional components and set up as part of a library of available features, e.g. the map or three-dimensional navigation device. This would increase the initial development costs but then decrease the modular costs of each multimedia package.

These features could be developed as component add-ons in multimedia creation packages such as Director, Viewer or Dreamweaver. This implies a consistent method of software development within these packages but that is becoming more common, with more reusable component based software development with the advent of Java, object oriented and applet type programming, and so would be feasible. Determining which specific features certain groups of users would need or prefer to use is more difficult. However research in educational multimedia has revealed that there is little user testing of software, and the testing that has been done has been on the content and its structure rather than the tools or structure of the multimedia.

Improving testing in these areas would substantially improve and promote user-centred design for multimedia.

20.12 Conclusions

Many researchers have suggested the need for more navigational research, though often this is for rather different reasons. Marchionini and Crane (1994) stated the following:

> The overall evaluation effort aims to inform general hypermedia application design, develop human computer interaction and information seeking behaviour theories, and add to our understanding of learning and teaching. Evaluating the effects of an emerging technology on complex cognitive processes forces evaluators to cope with interacting sets of ill-defined goals, limited or unknown criteria and subjective or complex instruments (p.6).

Canter, Rivers and Storrs (1985) work is relevant as they concluded that each system was very complex and the variables between system, task, and user and their complex interactions need to be examined. They determined that this analysis would allow indices or indicators to be developed which would in turn allow for further elaboration of user strategies. They considered, as I do, that the individual user is paramount and that it is essential to develop awareness of the way individuals prefer to navigate and work through multimedia software. They commented on two expert users, one methodical, and one erratic, with the following statement:

> While both might be successful in achieving their aims within a database/ expert system it is likely that they would be more effective if operating in a software environment that was more sympathetic to their individual styles. Design of such tailored systems must be preceded by an understanding of the navigational behaviour of the user (p.101).

The thesis aims have been to understand this navigational behaviour by assessing individual preferences in multimedia and proposing that multimedia design is adaptable for each user. The results of the empirical work have supported the hypotheses and promoted the use of individual navigational patterns and working strategies. The benefits and potential of multimedia for the individual have been explored and suggestions made for future design guidelines. Finally in conclusion on the main research question it has been shown that individuals do have distinct preferences for certain navigation patterns. Secondly on the subsidiary questions these preferences are affected by the system and navigation design, especially as not all of the navigation patterns are allowable in all multimedia designs. Thirdly the preferences relate to the way users prefer to work through the software, and despite there being no direct connection between specific navigation patterns and working strategies there are close relations between distinct types. Fourthly groups have distinct preferences, although the groups need to be further divided and there are sub groups of users with similar specific navigation patterns preferences. These subgroups need development, and the last two perspectives need further research and empirical work. The findings from the empirical studies of user's distinct preferences means that if we encourage, support and allow the development of each user's preferred methods of navigation then each user's individualised working experience may allow them to further develop their own learning and skills and perform to the best of their individual abilities.

This thesis has emphasised the importance of the development of skills and abilities to understand and use navigation patterns. It has shown that it is essential for designers to develop an understanding of the navigational behaviour of users. The other main linked theme is the development of the individual, which involves acknowledging how they prefer to use software and to encourage (or empower) their own development of navigation techniques. Bork's view (1995) supported this core theme from this thesis when he stated:

> Individualisation of learning is the key factor in making learning more effective. Every student is different, with different learning problems, different interests, different learning styles... The creation of highly interactive learning material makes it possible to respond to individual needs of each student...the computer can analyse student inputs and maintain a dynamically changing model of each student, so that each student can have an individualised learning experience (p.19).

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Appendices Index

APPENDIX 1 – Questionnaires and Interviews
Initial Questionnaire (Study 1 – Pre-test Questionnaire)

STUDENT NAME ....
JOB

AGE GROUP under 20 20-25 30+ 40+

HOBBIES/INTERESTS – INCLUDING TV PROGRAMMES – SUBJECTS TOPICS

HOME COMPUTER/WORK COMPUTER TIME SPENT USING IT

LEVEL OF EXPERTISE NOVICE INTERMEDIATE EXPERIENCED

LEISURE/ GAMES USED

SOFTWARE USED – PLEASE LIST (STATE IF FOR WORK OR AT HOME)

MULTIMEDIA USED – PACKAGES USED. HOURS USED, LEVEL ATTAINED

KNOWLEDGE LEVEL – EXPERTISE IN MULTIMEDIA GENERALLY
COMMENTS: -

LEVEL ATTAINED NOVICE INTERMEDIATE EXPERIENCED

HAVE YOU USED ENCARTA BEFORE? YES/NO
IF YES, PLEASE STATE WHICH PARTS AND WHAT FOR: -

LEVEL ATTAINED NOVICE INTERMEDIATE EXPERIENCED

LEARNING METHODS USED/ KNOWN ABOUT

DO YOU HAVE A PREFERRED METHOD OF WORKING THROUGH MULTIMEDIA? I.e. do you go through the index, or prefer to look at all sections, or browse randomly? Please state

INITIAL INTERVIEW CHARTS

GROUP										
YEAR/AGE GROUP										
ABILITY LEVEL										
HOBBIES/INTERESTS										
FAVOURITE TV										
HOME COMPUTER/ GAMES MACHINE										
LEVEL OF EXPERTISE										
SOFTWARE USED										
MULTIMEDIA USED										

MULTMEDIA SURVEY – STUDENT USAGE
POST OBSERVATION INTERVIEWS

Student **Date**

Package Used

General Overview

Personal preferences

Areas Looked at – Proportion

Likes/Dislikes

Ease of Use/ Use of help

User interface
Menus, icons, buttons easily understood

Operations consistent

Interaction with content

Presentation sufficiently informative

Presentation interesting

Screen easy to lead/look at

Learner's task challenging

Tasks valuable

Clear about what to do

Clear when achieved it

Comments on Tasks themselves

1) Browsing

Student **Date**

2) Set Navigation Task

3) Open task

Discussion Section

Knowledge/Interest levels

Navigation

Clear what options available

Clear how to get to where you want to be

Easy to find out what you have completed already

What wouldn't you do – either again or in future?

Student **Date**

Awareness of Structure – use/benefit from it

Strategies for using Multimedia, learning from it – before/after

Knowledge/ Information Used/Gained

Navigation techniques used and Future Navigation techniques

Overview/ General Comments/ Conclusion

POST OBSERVATION INTERVIEW

GROUP					
ABILITY LEVEL					
General Overview					
Knowledge Used/ Gained					
Areas Looked at Likes/Dislikes					
Navigation techniques used Help/ Ease of use					
Browsing Searching Layout/Awareness of Structure					
How improve/ Any problems					
Enjoy it/ Overview/ General Comments					

FOLLOW UP INTERVIEW

Student

Date

1) Browsing – What you browsed

2) Navigation Task (Roman Empire)

3) Open Task – What did you do?

4) Specific questions on set route

4.1) Emperors of Rome

Can you name three or more?

Do you know anything about these Emperors?

Student **Date**

4.2) Extent of Roman Empire (Geographical)

What countries did it cover at its height?

4.3) Roman Daily Life
What do you know about Roman Daily Life (include specific examples)?

4.4) What aspects of Roman Law have you found out about – be specific?

Do you have any previous knowledge of this subject – prior to the session?
– If yes please detail

5) General Comments?

MULTIMEDIA TAXONOMY

1) PACKAGE INFORMATION
   TITLE
   COMPANY/YEAR
   SUBJECT
   AGE RANGE
   AUTHORING LANGUAGE
   SIZE/FORMAT
   CONTACT

2) STRUCTURE/ INTERFACE

LINEAR/HIERARCHICAL	1 2 3 4 5
MAIN MENU/ SUBMENU	1 2 3 4 5
NAVIGATION – MAP	1 2 3 4 5
TYPE/ NATURE	1 2 3 4 5
LINKS	1 2 3 4 5
HYPERTEXT/HOT TEXT	
TEXT/ GRAPHICS/ VIDEO/ AUDIO MIX	1 2 3 4 5
AMOUNT/ NATURE	1 2 3 4 5
TASKS/ TUTORIALS	1 2 3 4 5
AREAS COVERED/ TYPE	1 2 3 4 5
AWARENESS OF STRUCTURE	1 2 3 4 5
PATHS FOLLOWED/ OVERLAPS	1 2 3 4 5
REPETITIONS	
USER INTERFACES	1 2 3 4 5
ICONS/ BUTTONS	1 2 3 4 5

3. FEATURES

PRESCENCE/ ABSENCE	**1 2 3 4 5**
TASKS/ EXERCISES	**1 2 3 4 5**
WORKSHEETS	**1 2 3 4 5**
CUSTOMOBILITY/ TAILORABILITY AMOUNT	**1 2 3 4 5**
NAVIGATION AMOUNT USED/ AWARENESS	**1 2 3 4 5**
HELP – NATURE	**1 2 3 4 5**
INDEX	**1 2 3 4 5**
FEEDBACK – POTENTIAL IMPROVEMENTS REPORT CAPABILITY	**1 2 3 4 5**
MULTIMEDIA EFFECTS SPECIAL EFFECTS – INNOVATIONS	**1 2 3 4 5**

4. USAGE

EASE OF USE	**1 2 3 4 5**
CONTROL – AMOUNT – AWARENESS BROWSING RATIO/ SEPCIFIC SEARCHES	**1 2 3 4 5**
PRESENTATION	**1 2 3 4 5**
INTERACTIVITY	**1 2 3 4 5**

5. EDUCATIONAL BENEFITS

DEVELOPMENT OF COGNITIVE SKILSS – RE-USABLE SKILLS ACHIEVEMENTS- ANALYSIS	**1 2 3 4 5**
KNOWLEDGE GAINED ENGAGEMENT/ENJOYMENT	**1 2 3 4 5**

6. OVERVIEW

CLASSIFICATION	**1 2 3 4 5**

Multimedia Research

User Response Sheet

Task 1

Time started --:-- Time finished --:--
Comments: -

Task 2 Route Used A B C D (circle)

Time started --:-- Time finished --:--
Comments: -

Task 3 Topic chosen --------------------------------------

Time started --:-- Time finished --:--
Comments: -

APPENDIX 2 – Empirical study tasks
Empirical Study tasks - Outline of tasks

ORIENTATION TOUR

Follow the Overview on the front of the Encarta Encyclopaedia

Introduction
Home Screen
Article Screen
Searching
Links to the WW web
Monthly update
More info
Media Features
Using Articles
Settings

Go through the following list of operations

Drop down menus – e.g. media – click and drag – move across
Pop up menus – e.g. Pinpointer on Find, closing to continue
Closing boxes – right hand cross, left hand open box
Back arrow to return to previous position
Backlist – go through what you have been to before
Selecting articles – article reduction
Related Articles
Use of pictures – Expand and Caption Bar
Using slider controls – select option
Find using Pinpointer

Using Word Processor

Select Tools on menu bar
Select Word Processor
Select words you want to copy – drag mouse over them
Pull down menu bar above text
Click on copy
Click on the word processor
Click on Edit and Paste

For pictures use: -

Copy image (top left corner arrow of picture)
Go to word processor
Choose edit and paste

Save or Print file by using the File Menu in word processor

NAVIGATIONAL PATTERNS IN MULTIMEDIA

EMPIRICAL STUDY – 2nd Study – Task Outlines

You will be using the multimedia package

Encarta 97

Follow the instructions through each sheet and record on the User Response sheet the time you start and finish each of the sections as well as any notes or comments.

Select Encarta Encyclopaedia Articles

Click middle box on top right to increase screen size

Note time started, move on to next sheet

Multimedia Research – Task 1 Outline

Task 1 – Browsing Exercise
15 minutes allocated, so you have to be selective
Look at Encarta Encyclopaedia Articles
Check out the Features list

Feel free to browse through the package as you want to.

List of features and what you will find on each drop down heading – for your information / reference.

Media Feature	**Online F (less useful)**	**Tools (use in last task)**
Media Gallery	Yearbook	Notemark
Interactivities	Weblinks	Browse Panel
Guided Tours	Downloads	Word Processor
Atlas	Encarta Online	
TimeLine	WW Web Tips	
Mind Maze		

Options

Copy	Open Media
Print	Settings
Views	Printer Set up
Text Size	

Find

Text Selection	Image Frame
Whole Article	Caption

Home – (Returns to beg)

Dictionary – Brings up dictionary

Home Info – Not very useful for this exercise
- More Info updated
- Gives related articles
  - Web Links
  - YrBk Article Updates
  - Further Reading

Multimedia Research – Task 2 Outline

Route A
Time started – make a note (25 mins allocated)

Do not follow any other leads or any hot text links (red text) keep to the prescribed route. Remember that time is limited, please make notes, - I'd like them afterwards

Follow this route:

Select Features

  Select Media Features

    Select Timeline

Move to 400 BC by –
  Picking up grey bar at bottom of screen and sliding right

Timeline
Your route now follows the timeline and its sequence of events, if you do get out of this, start again, by reselecting the timeline and then reselect the place where you left off.

Items on the Timeline are repeated – only look at each of the named areas on the line once

NB Articles in small boxes must be closed (top right hand box) before continuing.

Rise of Rome
- Romulus and Remus
- Paved Streets
- Oysters

Imperial Rome – AD100
- Augustus
- Colosseum
- Constantine the Great

Pompeii
- Marcus Aurelius
- Silk Road
- Alaric 1

End of Rome

If time allows continue into Expansion of Christianity – which gives some information on the fall of Rome.
Now progress to next sheet, Noting time finished on this section.

Multimedia Research - Task 2

Route B – 25 mins

Select Find

Pinpointer

Select Category

Then Select, History

Ancient History (should give 462 articles)

Type in Roman Empire (reduces list)

Select highlighted option on list and press return / mouse

Follow along route – first click outline box in bottom left for list of contents

You can use some links (highlighted words have connections to other areas), use backward arrow at top to return back, remember the time constraint – only a few links can be explored.

Roman Empire	Other items
Beginnings of Rome	Timeline
1st Century Consolidation	Timgad
2nd retrenchment	Housesteads
Empire at its Height	Roman Emperors
Spread of Roman Culture	Appian Way
Town & Cities	
Life in the Country	
Religion	
Decline and Fall	Constantine the Great
Roman Inheritance	Timeline

Back to Beginning of Empire – check progress – repeat anything interesting if you have time

Multimedia Research - Task 2

Route C – 25 mins

Go to Find – Pinpointer

Select Find Wizard at bottom of list
Media – Find Wizard follows each of the questions and select as follows

Word - Type in Roman Empire, press next

• Category – Select those History, Art and Literature, Sports Games, press next

Media – Any media, press next

Time – only those articles relevant to 500BC to 500 AD

Place – Europe

Select Roman Empire on Word – 24 Media Found

Go through selections at own pace and in the order you want to, make notes on sheet, you may follow up a few of the links if you want to but remember the time constraint

To return to Pinpointer, click back arrow at top of page (next to Options)

Multimedia Research - Task 2

Route D

Please use Encarta to find out as much as possible in 25 mins on the topic:

The Roman Empire

Get a general overview first and then look at specific areas, you will be asked some questions on this at the end of the session

Select the areas you want to look at yourself but you could look at:

Roman Empire

Roman Art and Architecture

Roman Republic

And then if time, follow up more specific areas such as:

Roman Britain
Roman Forts
Roman Baths
Roman Roads
Roman Villas
Roman Mythology
Latin Literature

But follow your own selection – i.e. these do not have to all be searched or done in any particular order.

Be careful with your time you only have 25 mins

NB If using Pinpointer, press start again before typing selection to clear previous entries

Multimedia Research - Task 3 - 2nd Study

Open Question – Final Task

Please decide on a specific topic to look at. This can be a person, place or time, subject etc., but it should be your own choice.

You have 25 minutes to find out as much as you can about this.

Use as many or as few sources as you wish, but you should decide **quickly** on the topic you want to look at.

Please write the name of the topic down on your User response sheet

Please make notes as you go along, all the screens you use will be noted, but you may like to make notes of your progress or the areas you've looked at.

The following may help:

Notemark – makes notes on important features – you can annotate important sections

Browse Panel – Enables you to browse freely

Word Processor – Simple word processor to make notes, or hand write on your sheet(s)

Note anything you're interested in, with a brief summary at the end and comments on the material you've seen

Questions for Final Interview (continue overleaf if necessary) – 2nd Study

1) Emperors of Rome
Can you name three or more?

Do you know anything about these emperors?

2) Extent of Roman Empire (Geographical)
What areas/ countries did this cover at its height?

3) Roman Daily Life
What do you know about Roman Daily Life (include specific examples)?

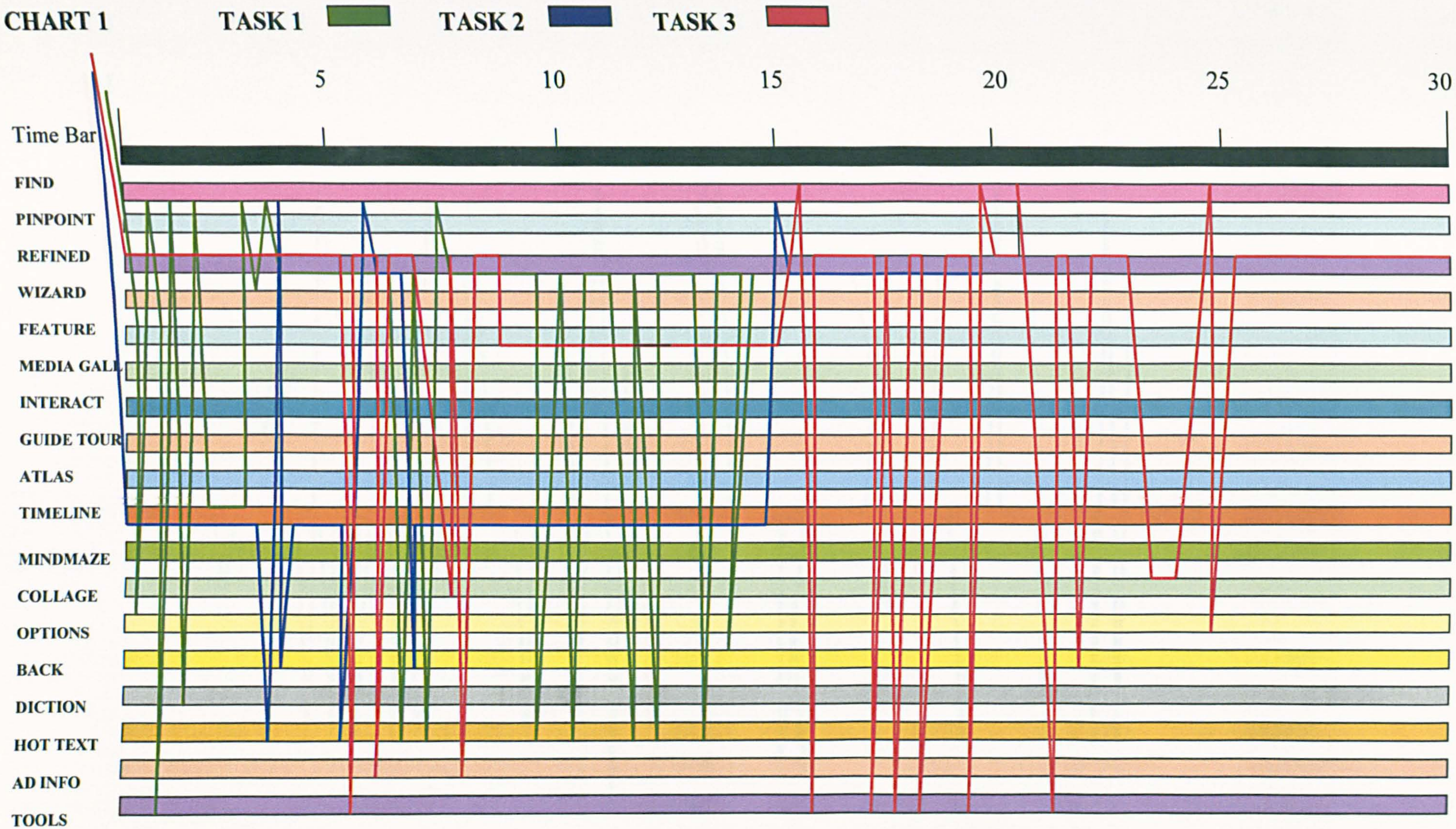
4) What aspects of Roman Law have you found out about? – Be specific

Do you have any previous knowledge, before the session about the Roman Empire? If yes, please detail and say if this helped you

APPENDIX 3 – Navigational Charts - Study 2

Navigational charts

Navigational charts 1 – 20 For each Participant in Study 2



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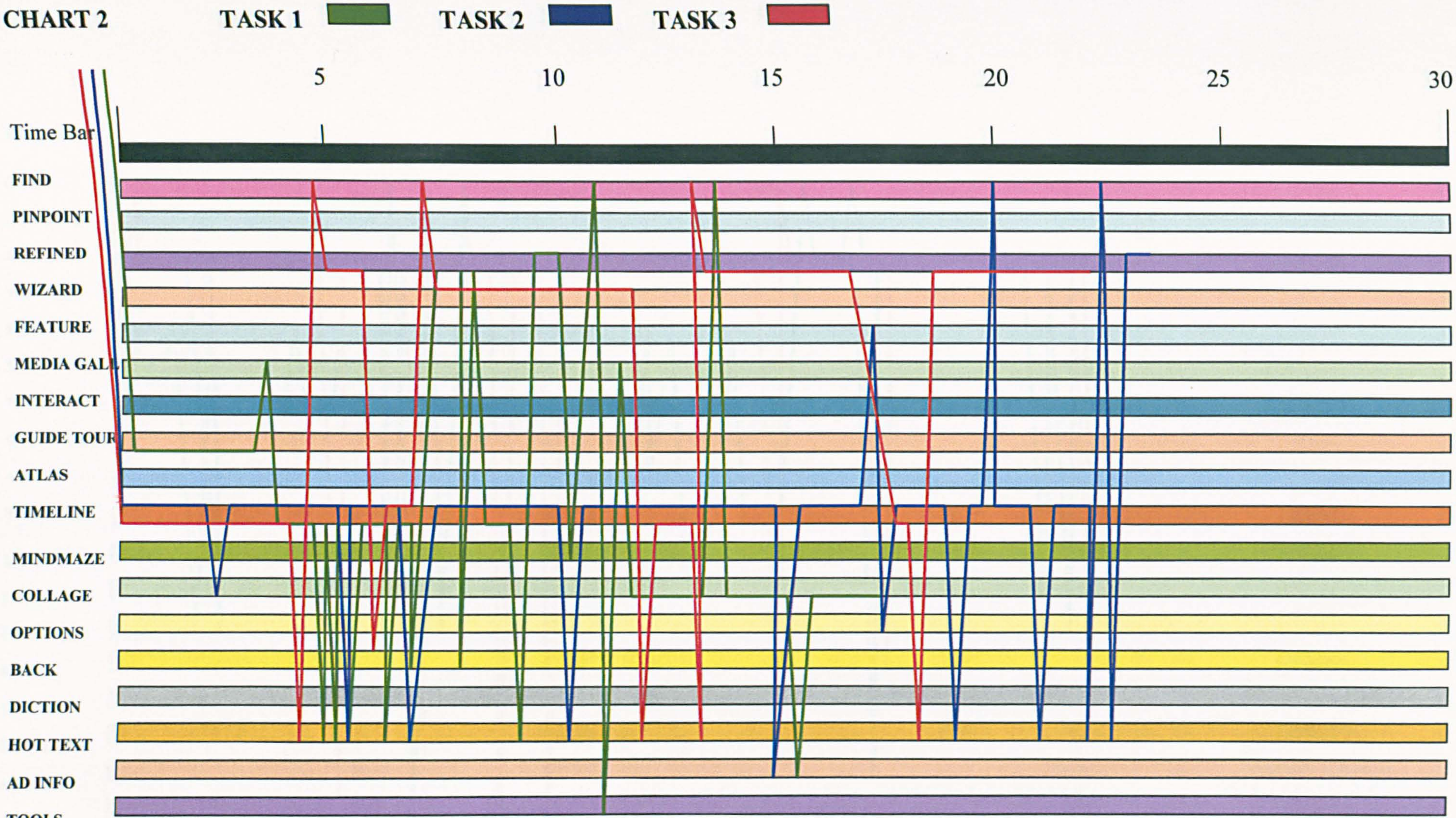

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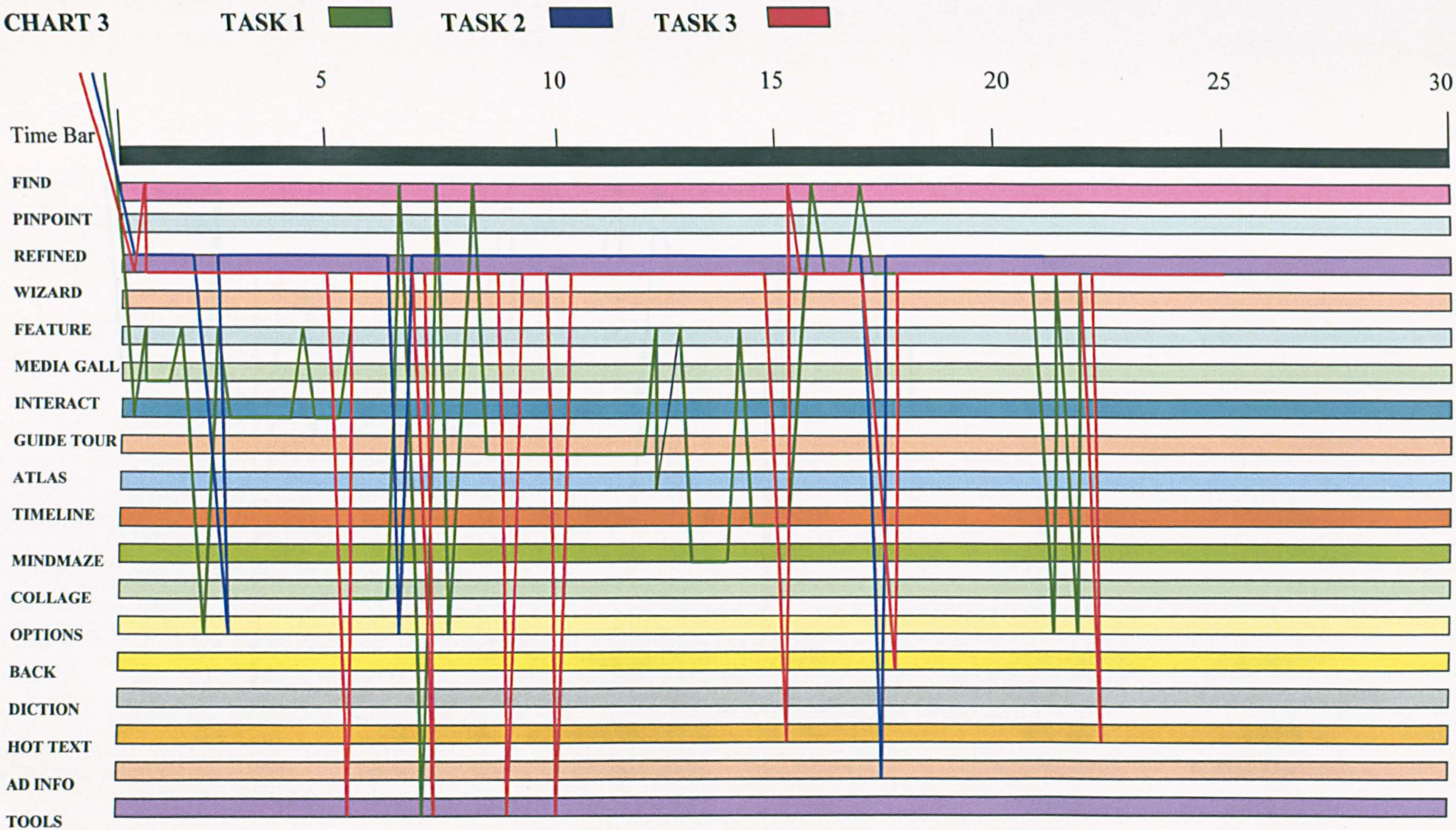

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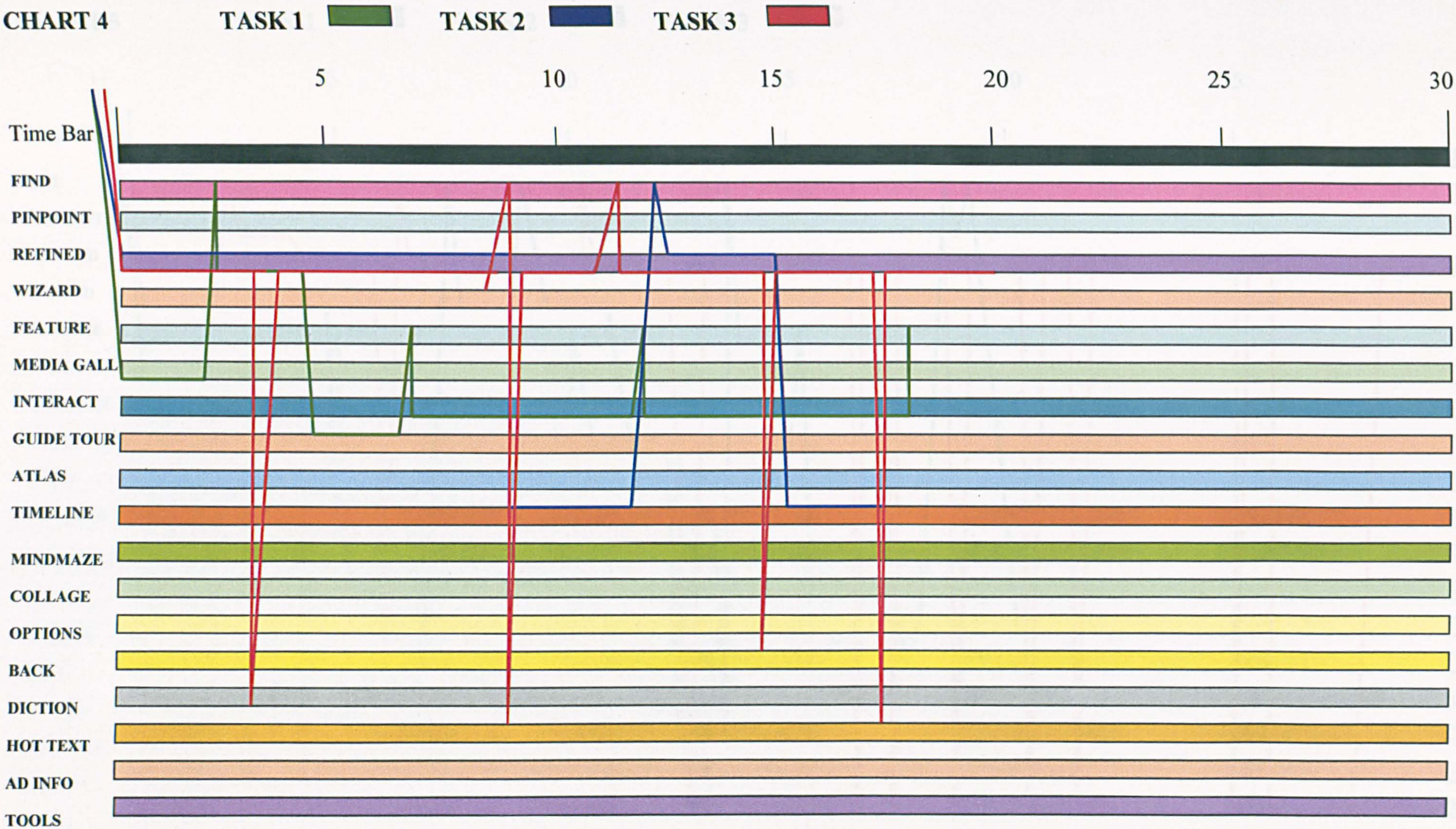

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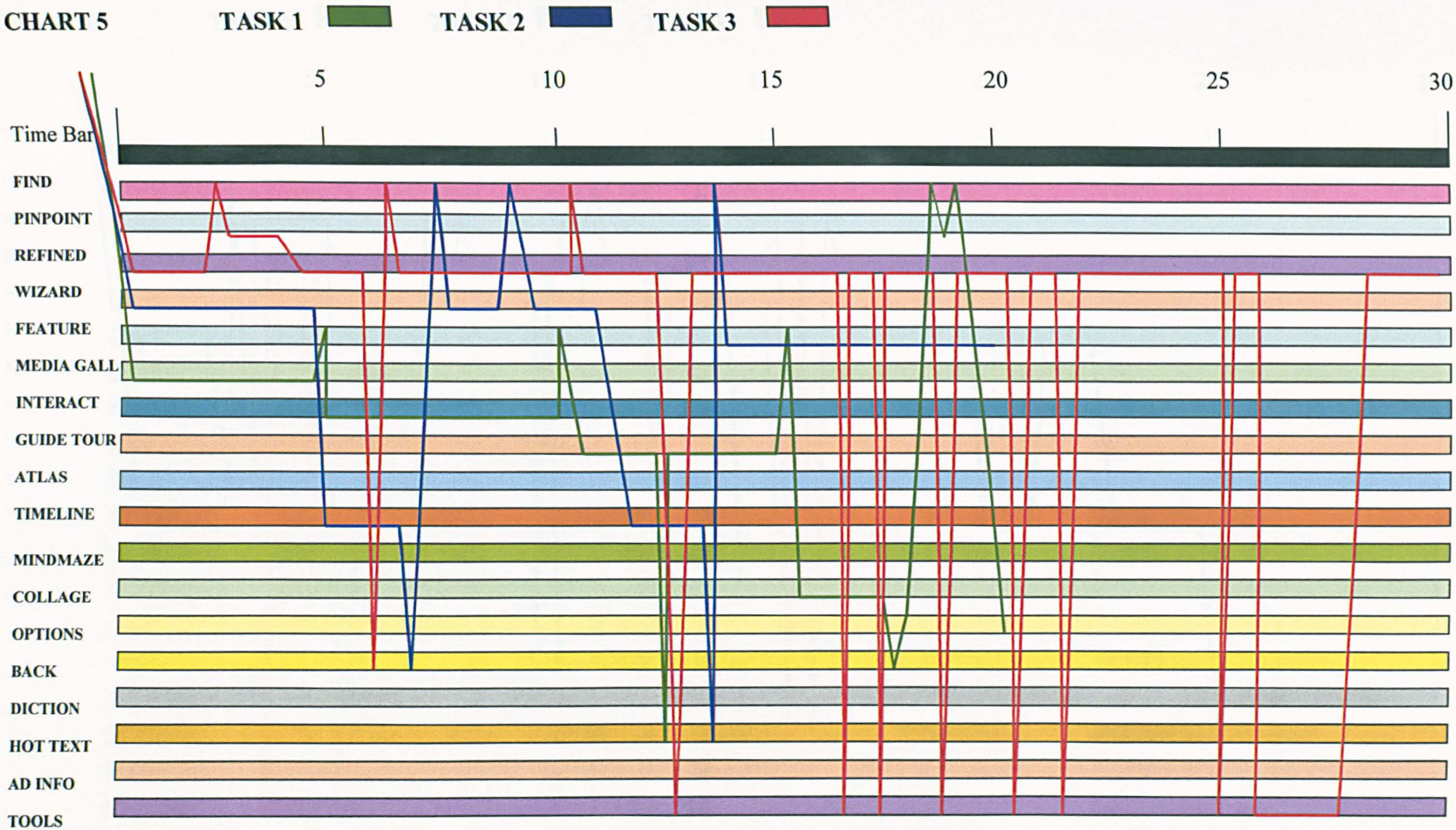

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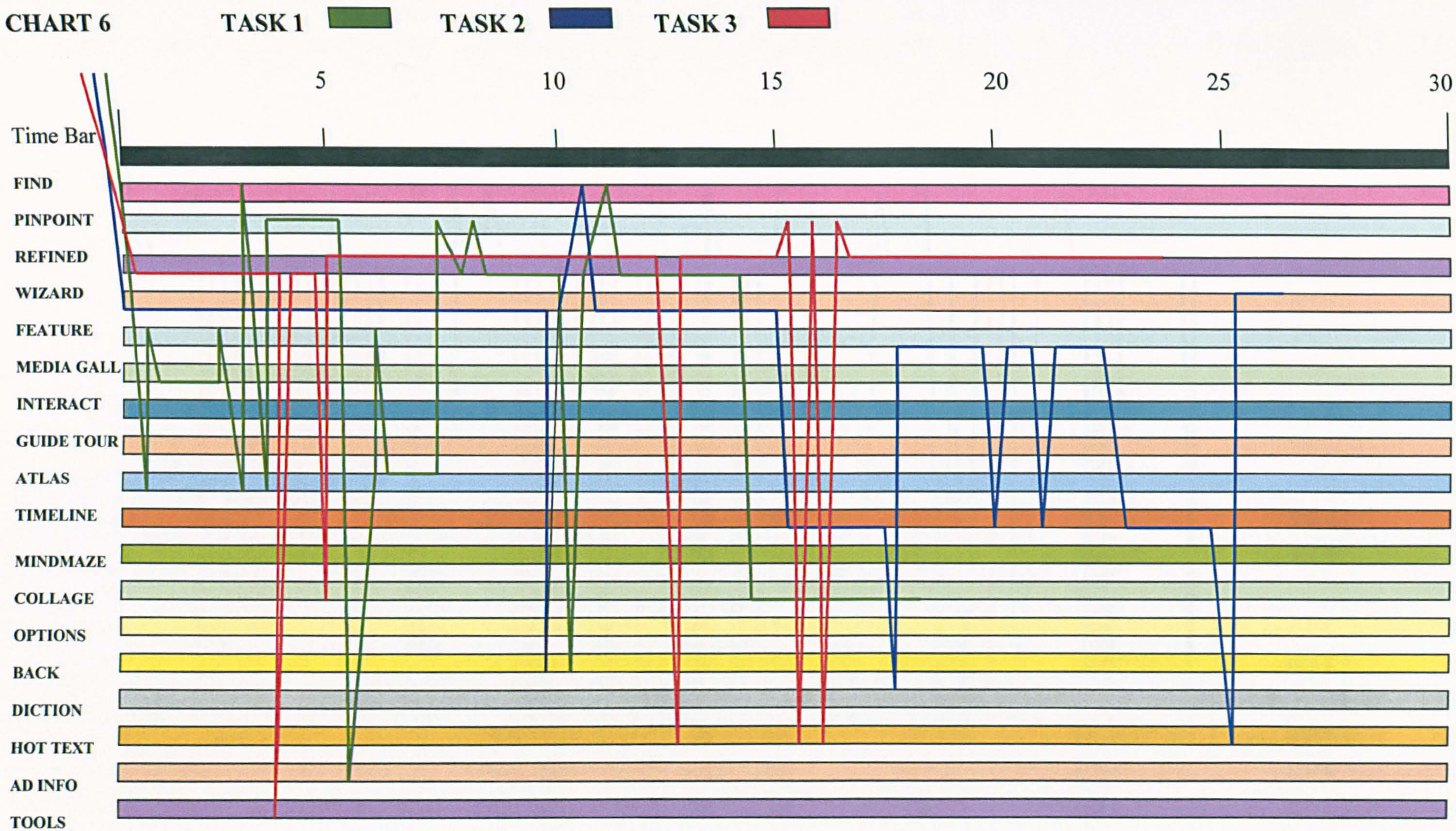
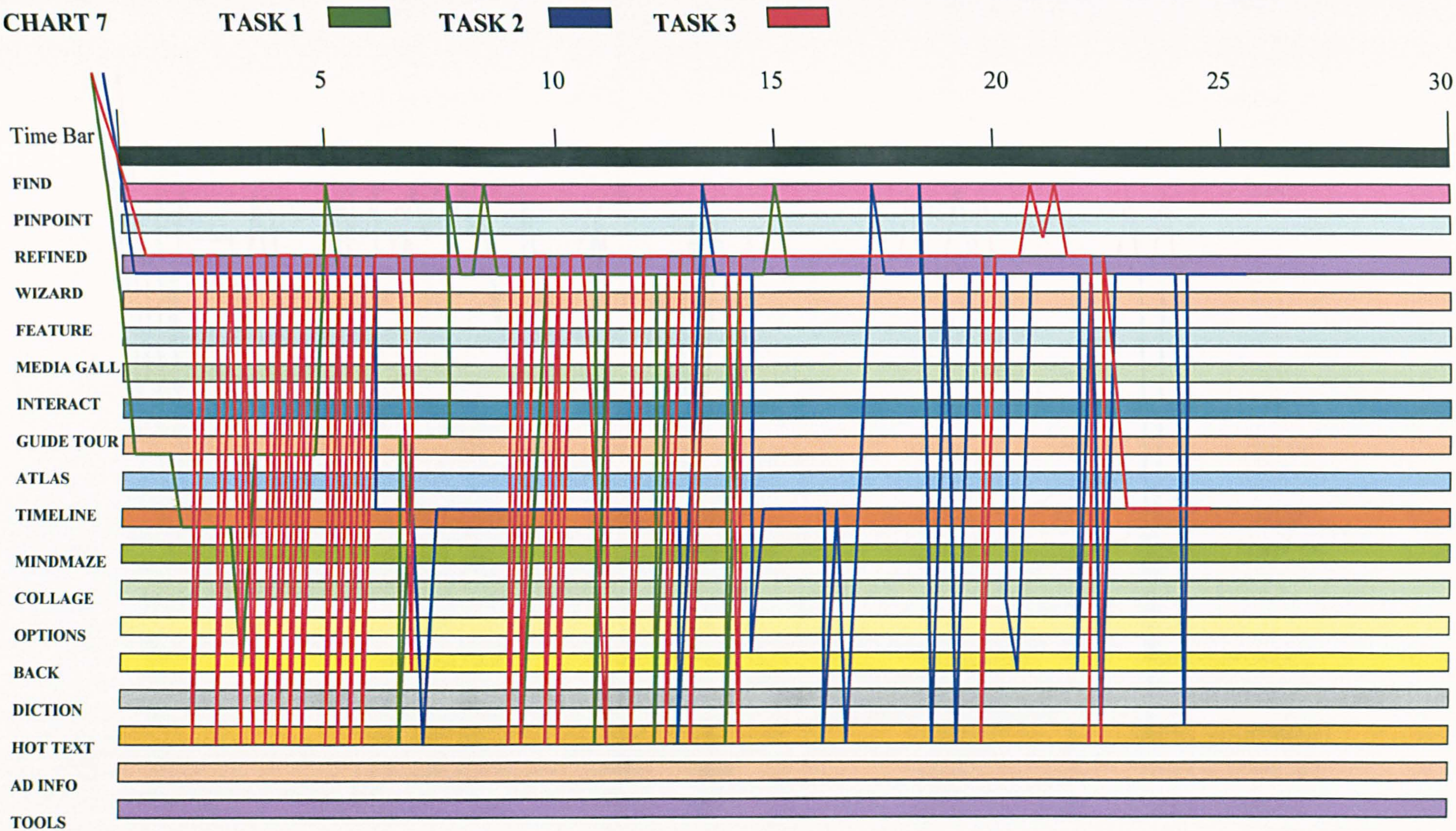


NAVIGATIONAL CHARTS

REF: 06 BI

CHART 7



NAVIGATIONAL CHARTS

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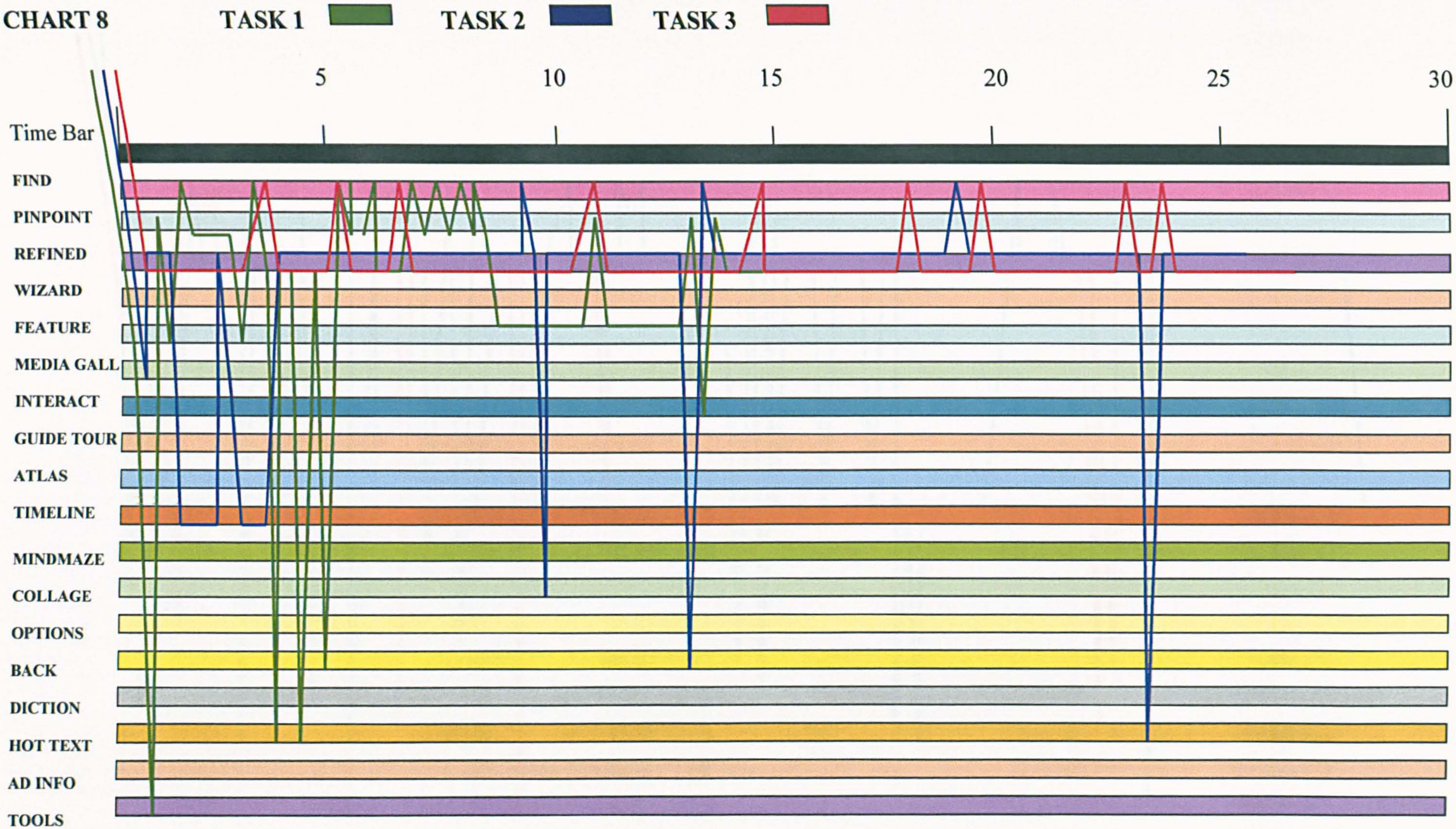
CHART 8



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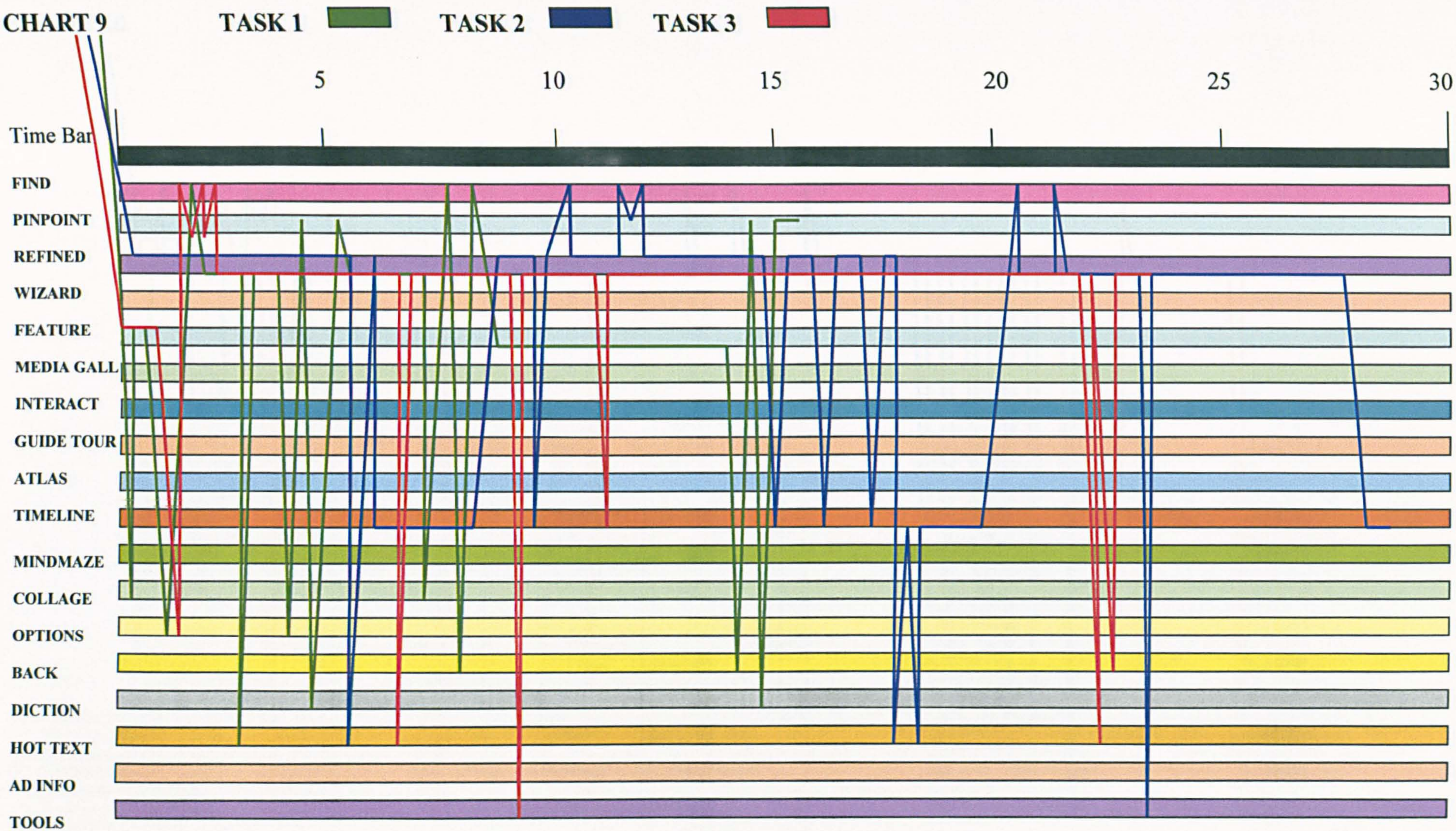

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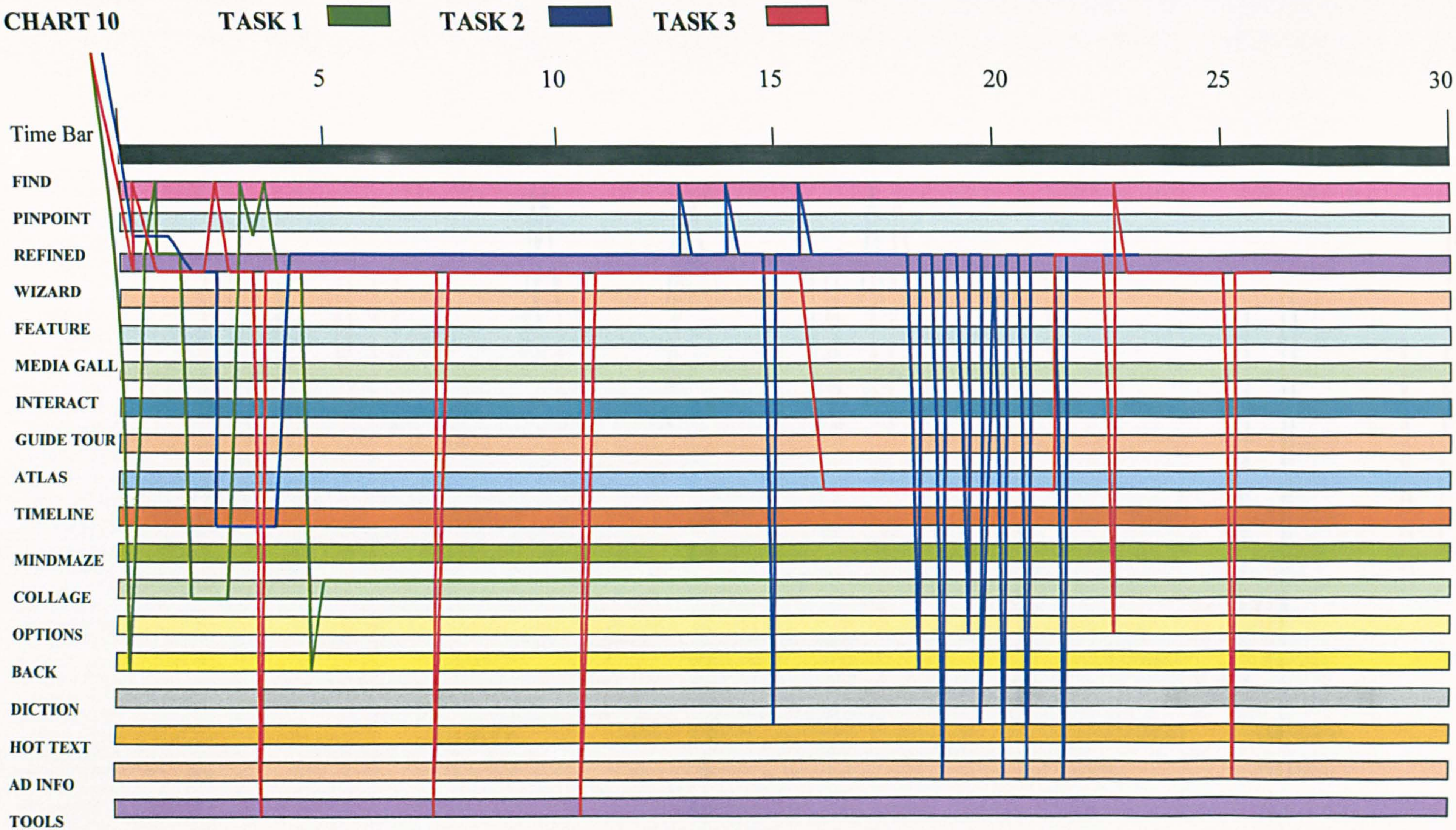

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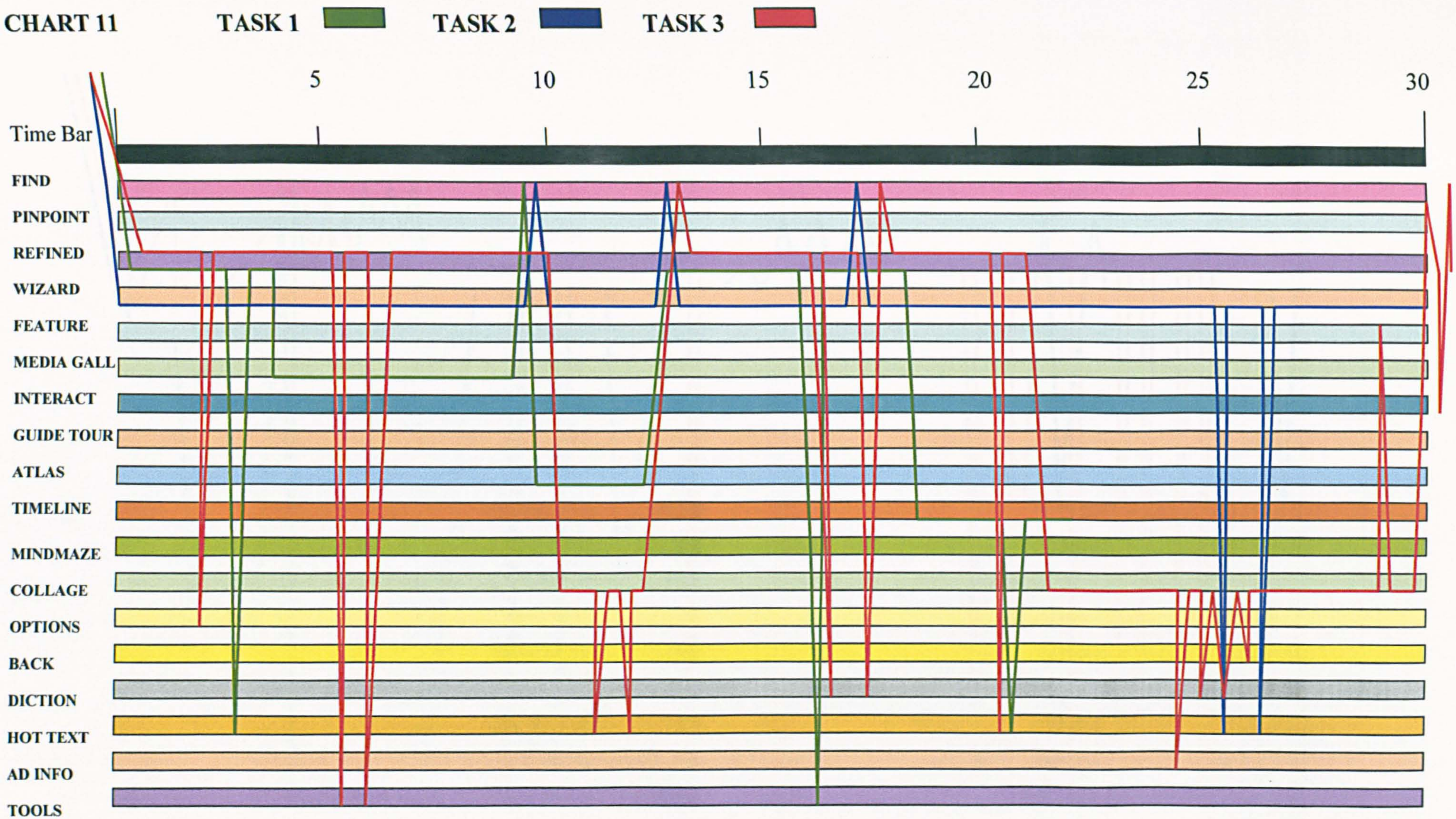

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CHART 12 TASK 1 TASK 2 TASK 3

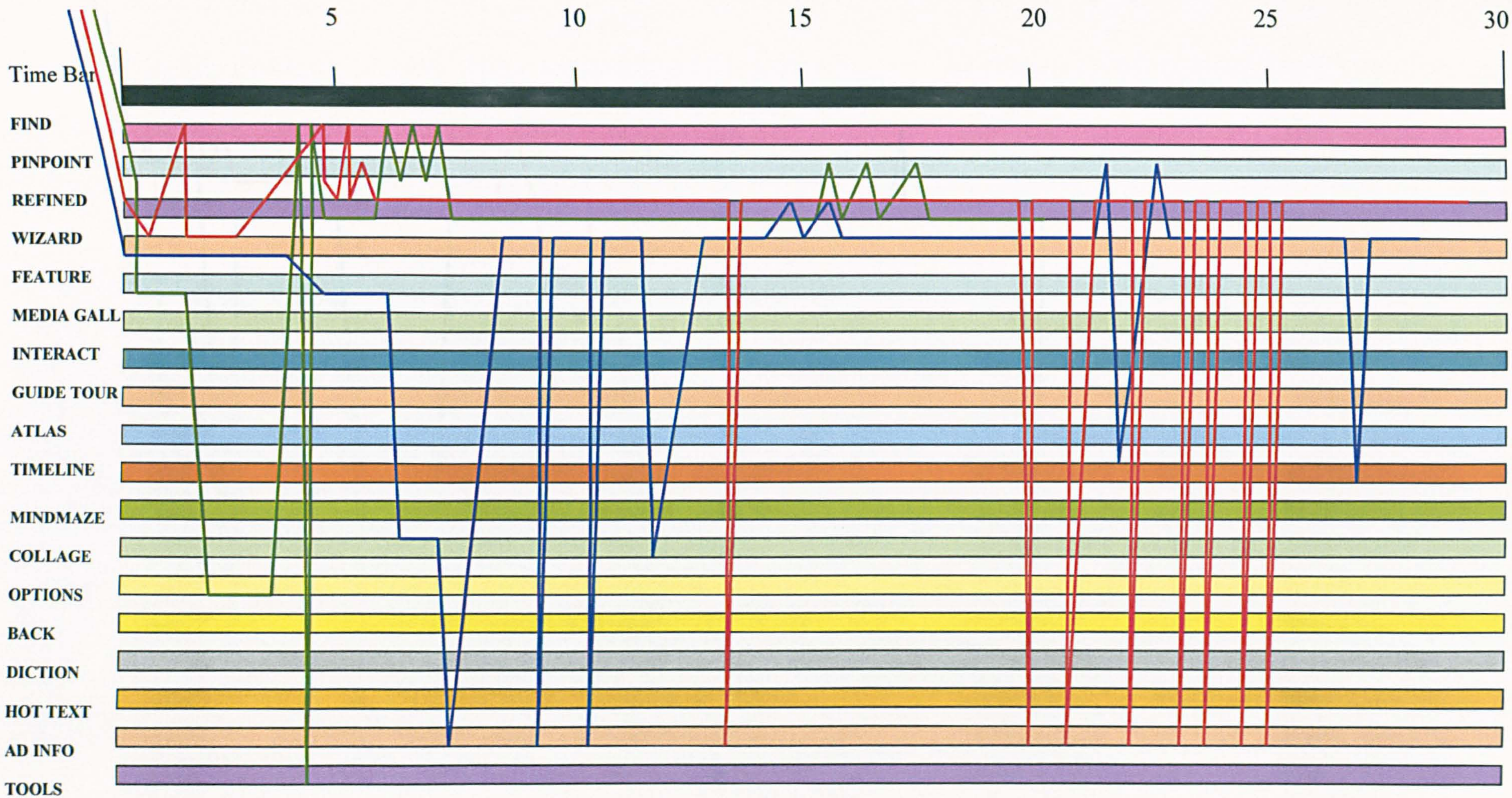

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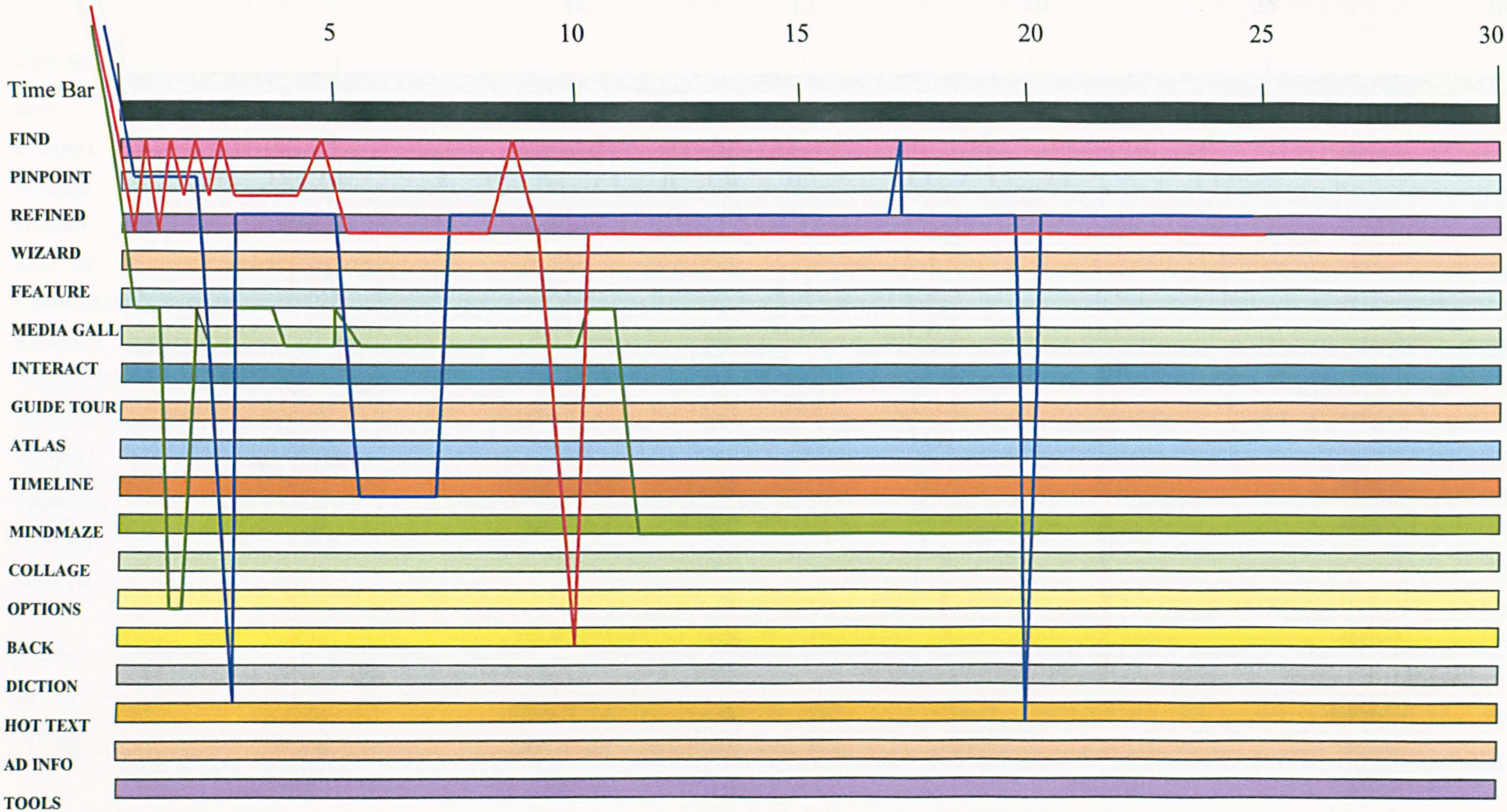
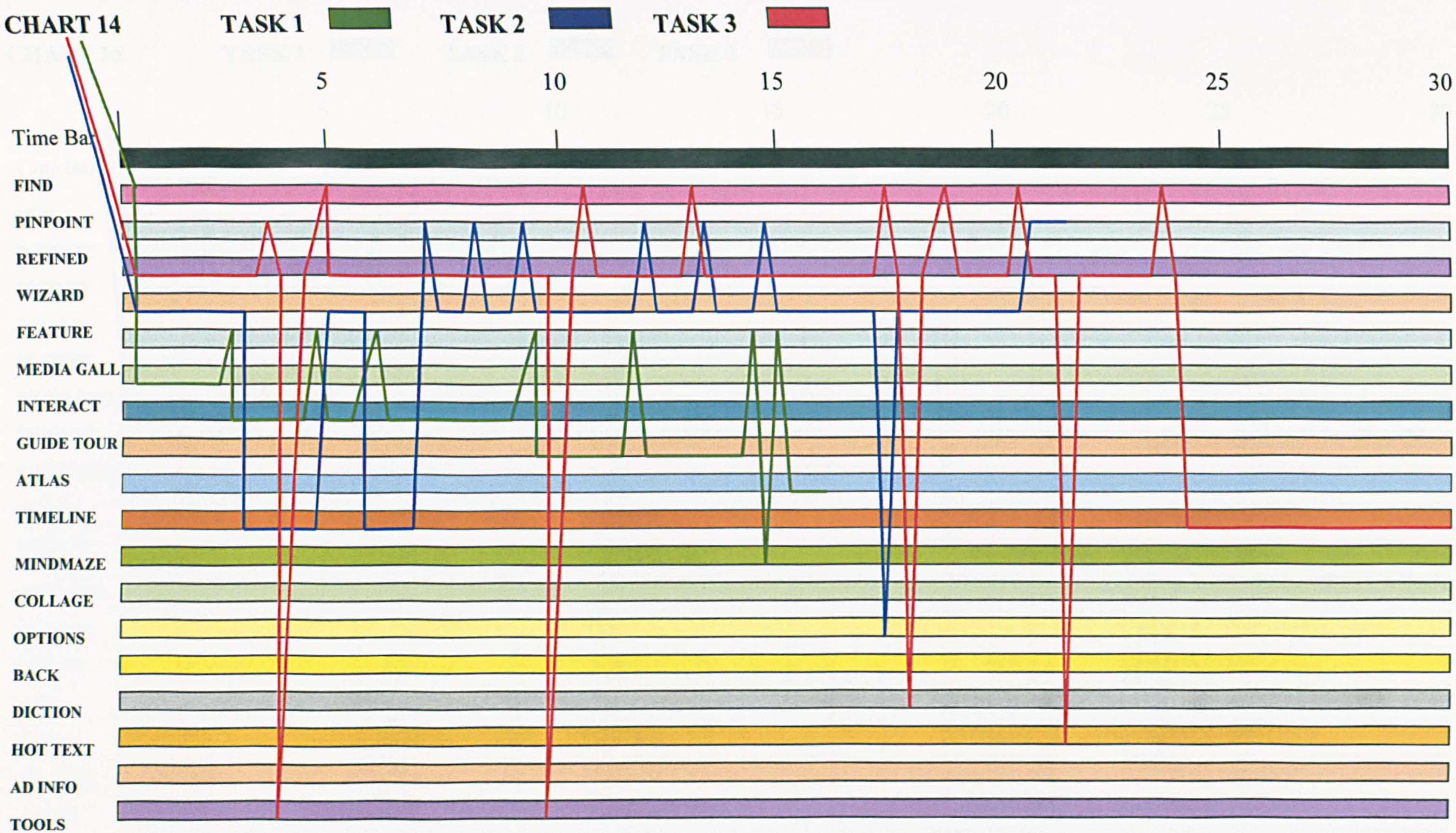
CHART 13 TASK 1 TASK 2 TASK 3



NAVIGATIONAL CHARTS **REF: 13 CO**



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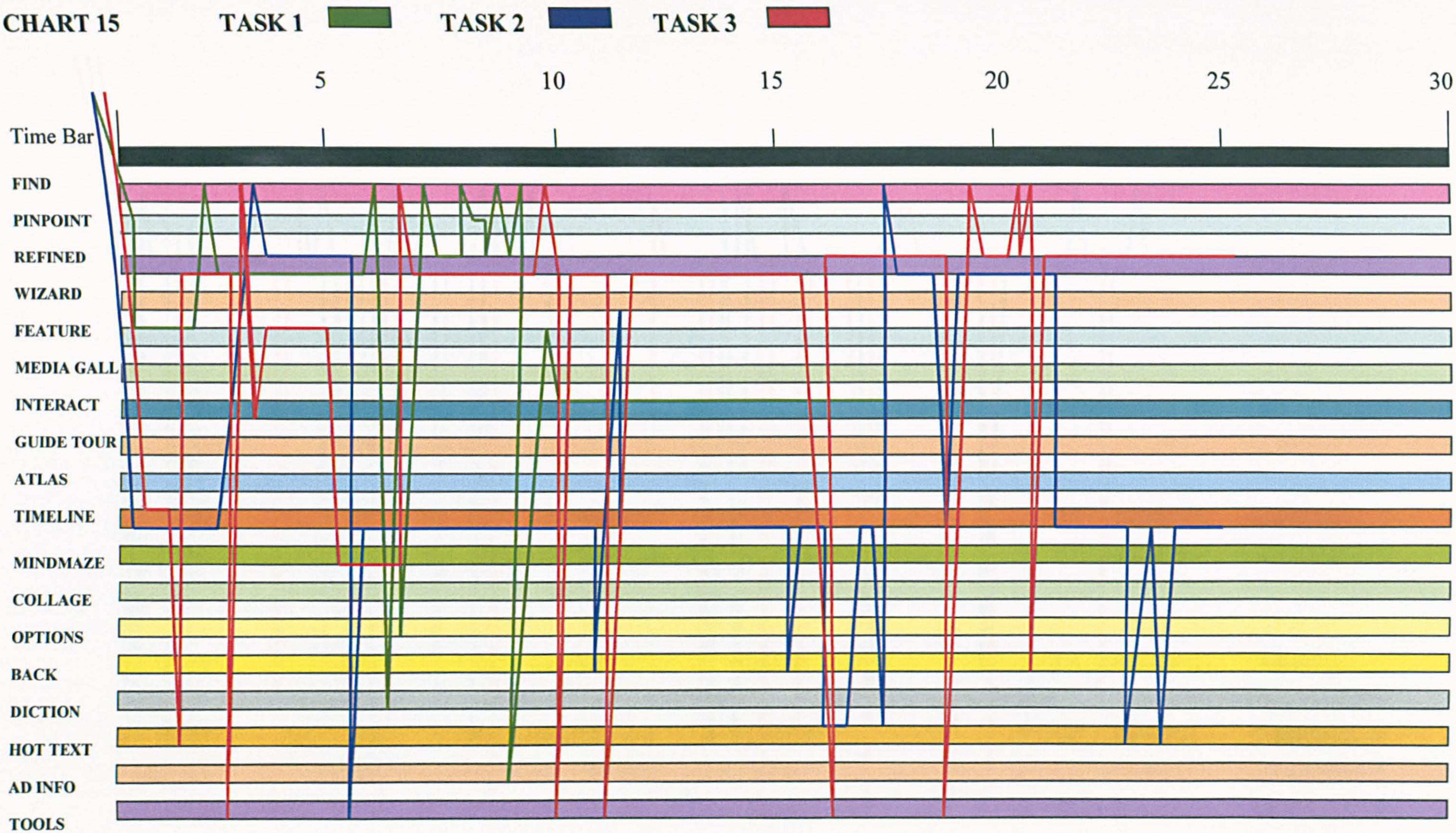

NAVIGATIONAL CHARTS

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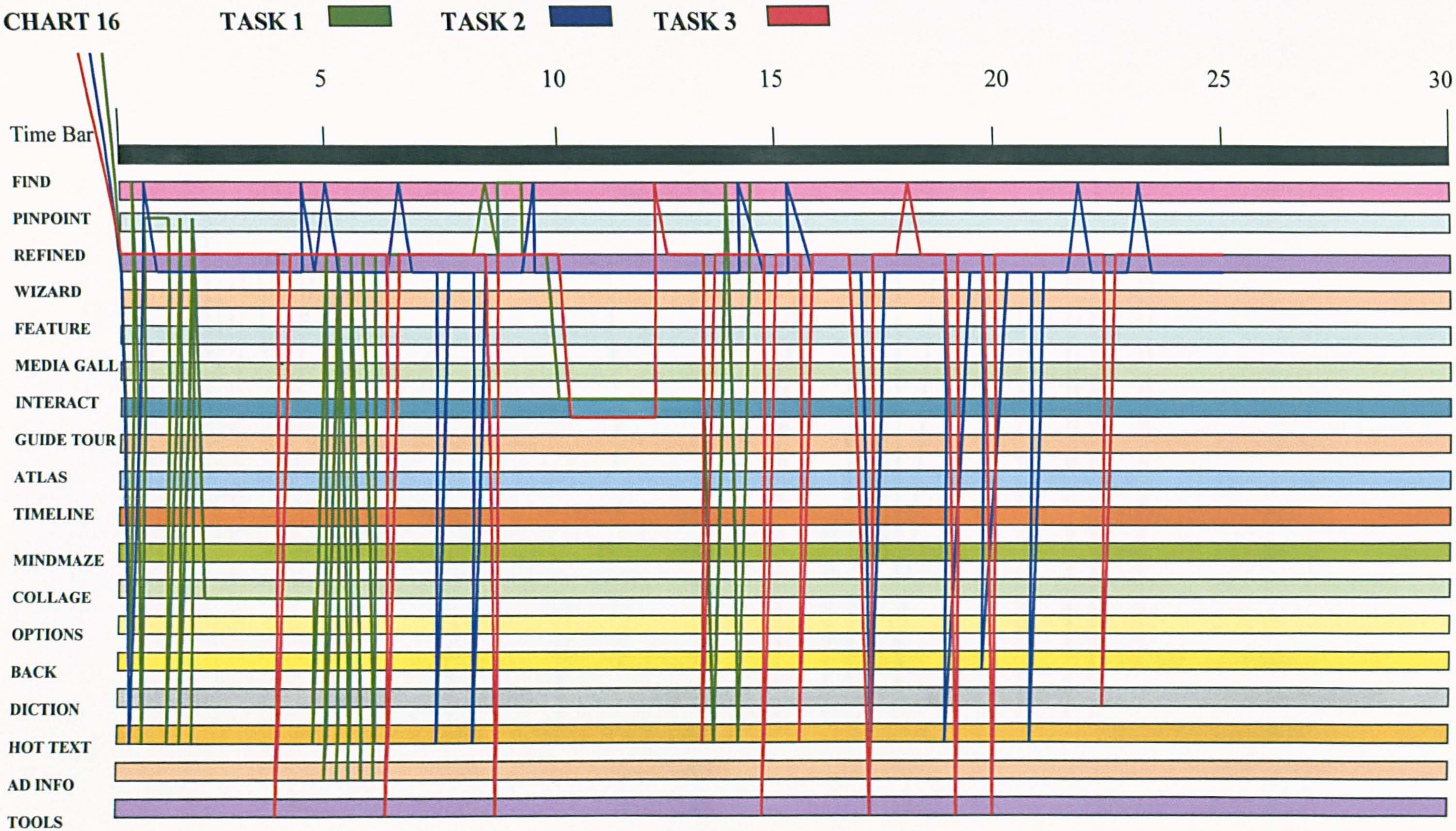
CHART 16



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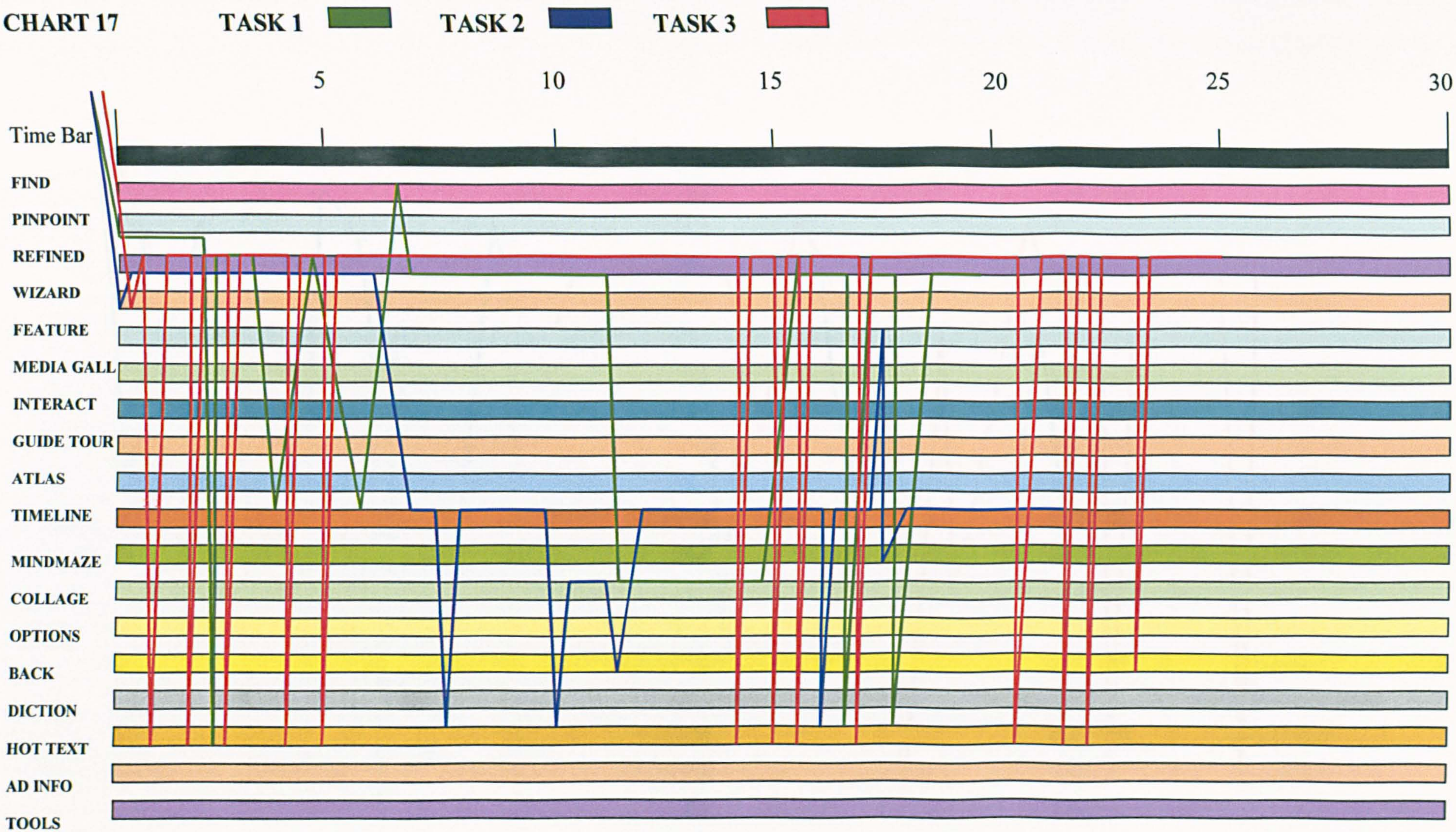

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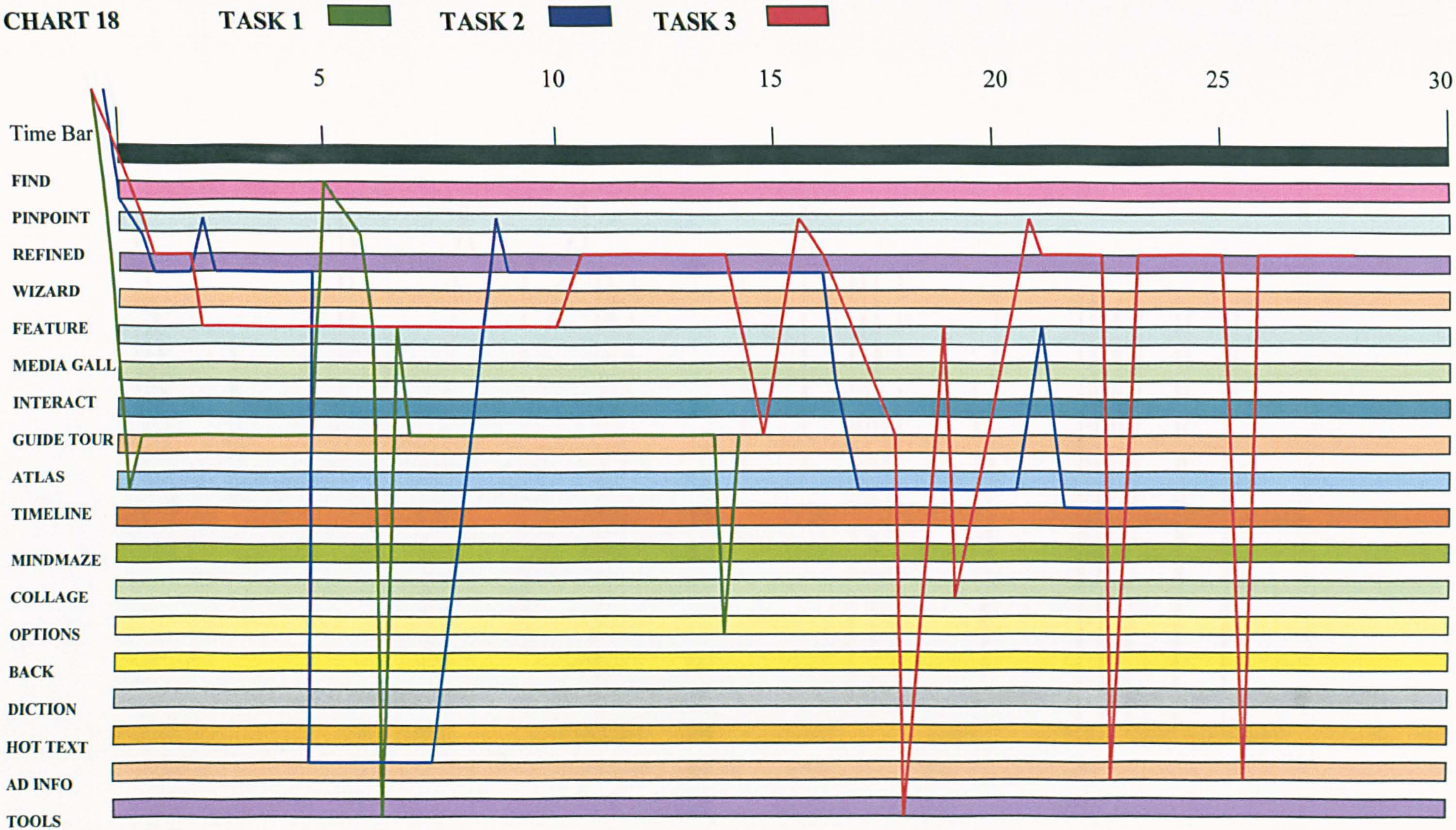

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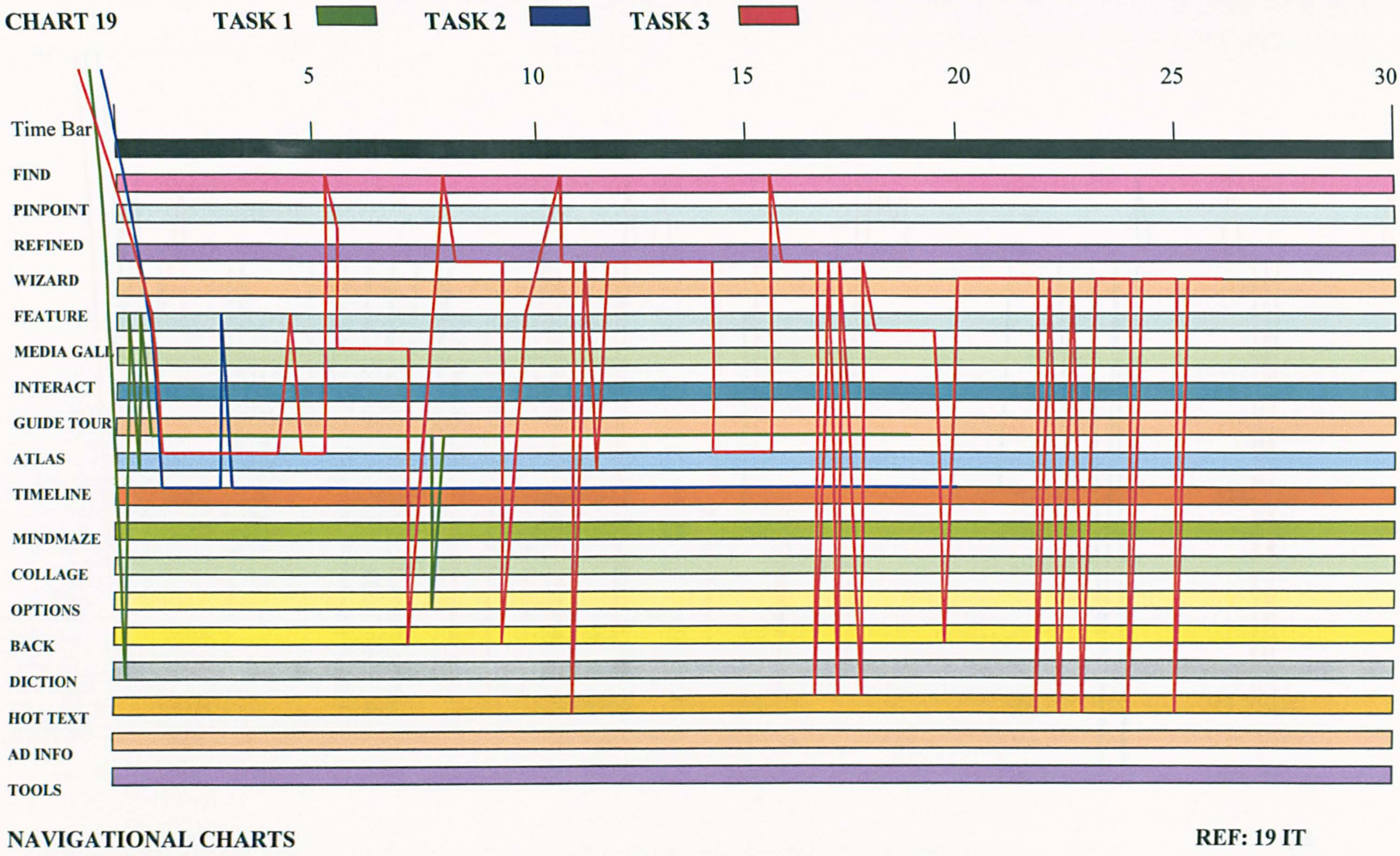
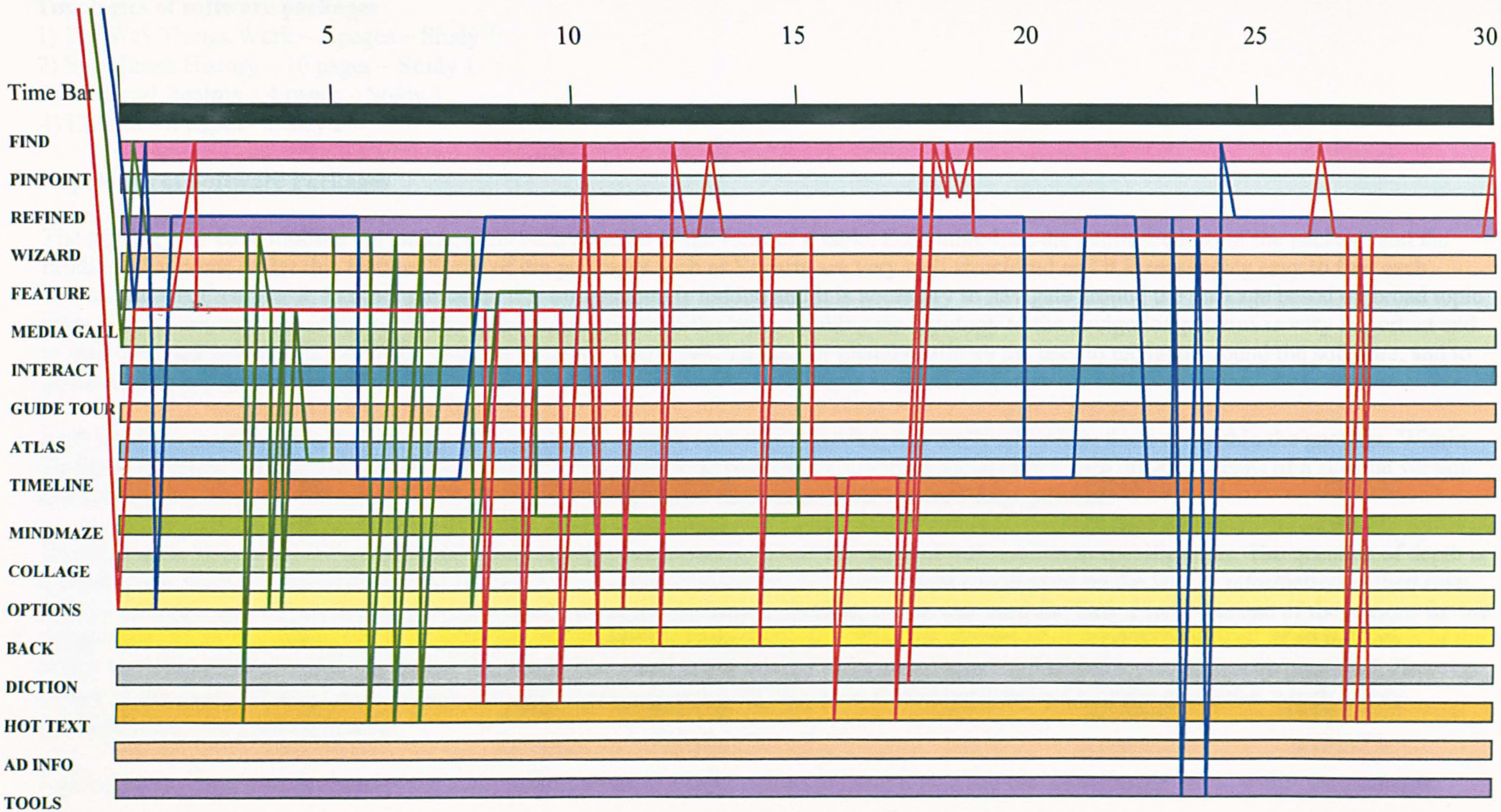


CHART 19
TASK 1
TASK 2
TASK 3
5
10
15
20
25
30
Time Bar
FIND
PINPOINT
REFINED
WIZARD
FEATURE
MEDIA GALL
INTERACT
GUIDE TOUR
ATLAS
TIMELINE
MINDMAZE
COLLAGE
OPTIONS
BACK
DICTION
HOT TEXT
AD INFO
TOOLS
NAVIGATIONAL CHARTS
REF: 19 IT

CHART 20 TASK 1 TASK 2 TASK 3



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APPENDIX 4 – Topologies of Software Packages Study 1 and Study 2

Topologies of software packages

1) The Way Things Work – 2 pages – Study 1
2) Eyewitness History – 10 pages – Study 1
3) Medieval Realms – 4 pages – Study 1
4) Encarta – 6 pages – Study 2

Topologies of Software Packages

The topology for each multimedia package has been detailed in the form of a table. Each table lists the major sections of the package and the headings that come under this feature. Some of the packages such as Encarta are very well structured and it is reasonably easy to find each section and what's under it. In other packages this information is hidden and it is necessary to navigate around the package based on broad topic areas without any concept of the subheadings or subdivisions of the topic. Linking the topology to the navigation patterns is very important and in well designed software is should be possible to create a navigational map or plan that allows the user to navigate around the software, and to go directly to relevant sections.

Each topology therefore lists in sequence the subheadings under each major heading and the levels where these are within the package. Within the thesis the basic structure of the package and how the navigation patterns have been associated has been done by means of a skeletal version of these topologies and a diagrammatic version of the navigational patterns so these can be easily matched.

The topologies also reveal the complexity of the packages and to some extent the depth of information in specific areas. The question of depth is a difficult one as this varies both between packages and within each package. Several users commented on the lack of information in their own specific packages as well as the copious amount of text on the Romans in Encarta, which was used for Task 2 (and was one of the reasons for the selection of this topic). Hence the topologies give an idea of the complexity as well as the content of each package as well as an indication of the layout. Creating a two dimensional layout has meant that some of the parallel links across areas and within topics cannot be displayed. However further exploration of the structure of the packages would require having the three-dimensional and multimedia navigation which is only available within the package itself.

Topologies are described in terms of the main subject areas, the subdivisions of these topics and the approximate levels within the packages.

The Way Things Work Topology (2 pages)

Level 1	Level 1	Level 1	Level 1		Level 1
Workshop	Machines	Principles of Science	History	History Level 3 Options	Inventors
Level 2	Level 2	Level 2	Level 2	Level 3	Level 2
Trumpet	Alphabetical	Electromagnetism	Antiquity 7000 BC-AD 1250	7000 BC Ship 4000 BC Percussion Instruments 3500 BC Plow 3000 BC Sailboat 3000 BC Brass Instruments 3000 BC Woodwind Instruments 1000 BC Candle	Archimedes Faraday Benz Wright Bros. Kilby Volta Bell Jannsen Zworykin
Spider	e.g. for A	Sensors & Detectors	The Birth of Science 1251 - 1700	1288 Starting Gun 1509 Clockwork motor 1589 Toilet Tank 1592 Thermometer 1600 Microscope	Level 3 Book of Inventors A examples Messrs Appleby Kunitaka Aramura Archimedes William Armstrong
Electric current	Airliner Wing	Gears and Belts	The Industrial Revolution 1701 - 1850	Examples - 1786 Clutch 1786 Electric Circuit	B - James Barron Alexander Bell
Camera	Alarm, Burglar	Springs	The Steam Age 1851 - 1940	1851 Rotary Pumps 1859 Binoculars	C- Georges Claude George Cayley
Bubble Machine	Astronaut Manoeuvring Unit	Screws	The Silicon Age 1941 - 2000	1948 Photocopier 1950 Disk Drive	D-Ian Donald James Dewar
Test tube	Aerosol, Spray Can	Inclined Planes			
Wheel	Airplane	Flying			
Film reel	Amplifier	Pressure			
Cog	Auger, Construction	Friction			
Power drill	Air Conditioner	Photography			
Saw/Hammer	Airship	Floating			

Bellows	Anerdoid Barometer	Electricity				
Megaphone	Autopilot	Pulleys				
Bunsen Burner	E.g. for B	Cams and Shanks				
Test tube	Bathroom Scales	Wheels				
Glass jar	Bell, Electric	Sound				
Firework	Boat, Sail	Magnetism				
Spanner	Balloon, Hot Air	Light and Images				
Book	Battery	Computers				
Light bulb	Binoculars	Heat				
Timer	Bourdon Gauge	Levers				
Hot drink	Barometer, Aneroid etc	Telecommunications				
Telephone						

Main Menu Items continued

Level 1	Level 1	Level 1	Level 1	Level 1
Back	Index	Options	Help	Mammoth Movies
Level 2	Level 2	Level 2	Level 2	Level 2
Returns to previously	Index of items and Inventors	Copy	Help with each section	Several movies e.g.
Selected item		Print		On Mammoth Potential
		Page Setup		

Way Things Work Topology – 2^{nd} Sheet

Eyewitness Topology (10 pages)

Ancient World Up to 500 BC	**Classical World 500 BC - AD 500**	**Age of Great Religions AD500 - 1100**	**Age of Conquerors 1100 - 1492**	**Age of Explorers 1492 - 1600**	**Expansion & Trade 1600 - 1700**	**Age of Revolution 1700 - 1825**
Level 2	Level 2	Level 2	Level 2	Level 2	Level 2	Level 2
Prehistoric World	Europe	Europe	Europe	Europe	Europe	Europe
Europe	Africa/ Mid East	Africa/ Mid East	Africa/ Mid East	Africa/ Mid East	Africa/ Mid East	Africa/ Mid East
Africa/ Mid East	The Americas	The Americas	The Americas	The Americas	The Americas	The Americas
The Americas	Asia & Australia	Asia & Australia	Asia & Australia	Asia & Australia	Asia & Australia	Asia & Australia
Asia & Australia						
Level 3	Level 3	Level 3	Level 3	Level 3	Level 3	Level 3
Prehistoric World	Europe	Europe	Europe	Europe	Europe	Europe
Level 4 Plains Hunter- Level 5 Primitive Weapons The Mammoth Hunters Modern Humans Key Dates Fact File	Level 4 Roman Life Level 5 Roman House Centre of Empire Pompeii Roman Society Trade &Agriculture The City of Rome Fact file 2	Level 4 Vikings &Normans Level 5 The Viking World Memorial Stone Sea-Raiders Trading & Raiding Viking Society Key dates Fact file 1&2 William t. Conqueror Roger 11 of Sicily Erik the Red & Leif	Level 4 Re-conquest of Spain Level 5 The Reconquista Christian Spain Key dates Fact file Isabella of Castile El Cid Alfonso VI	Level 4 Tudor England Level 5 Shakespeare's Theatre Spanish Armada The Tudors Elizabethan England Key Dates Fact File Mary, Queen of Scots Henry VIII Elizabeth 1 Thomas Cranmer	**Thirty Year War** Siege Magdeburg Causes Thirty Year War The Treaty of Westphalia Sweden's Role in the War Key Dates Fact Files 1& 2 Richelieu The Great Elector Wallenstein Ferdinand II Christian IV Gustavus Adolphus	Level 4 **Russian Conquests** Level 5 Growing Empire Balailaika Modernisation of Russia Partition of Poland Key Dates Fact File Peter the Great Catherine the Great
Level 4 The First Humans Level 5 Human Development Human Ancestors Key Dates	Level 4 Roman Empire Level 5 Roman Expansion Roman Legionary The Rise of Rome Imperial Rome Roman Emperors The Roman Army	Level 4 Monks & Monasteries Level 5 Lindisfarne Gospels Monastic Orders Key Dates Fact File St. Teresa of Avila	Level 4 Medieval Europe Level 5 Magna Carta Towns & Fairs The Middle Ages Peasant Life Medieval Nobility Monarchs &	Level 4 The Renaissance Level 5 Leonardo's Love of Learning Rebirth of the Arts The Renaissance Medici Florence European Battleground	Level 4 The Sun King Level 5 Life at Court Louis XIV's France Culture in the 17th Century Key dates Fact File	Level 4 Rise of Prussia Level 5 Prussion Success Enlightened Rulers Key Dates Maria Theresa The Great Elector Frederick William I

	Key Dates Fact File 1 & 2 Diocletian Constantine the Great Zenobia The Gracchi Hannibal Julia Mamaea Augustus Stilicho Julius Ceasar	St Ignatius of Loyola St. Francis of Assisi Thomas Aquinas	Governments Key Dates Fact File Philip IV John of England Eleanor of Aquitaine Charles IV Thomas a Becket	Key Dates Fact File 1&2 Cosimo De Medici Francis 1 Leonardo da Vinci Erasmus Lucrezia Borgia Alexander VI	Richelieu Madame de Marie de Medici Louis XIV	Frederick the Great
Level 4 The First Farmers Level 5 Fertile Crescent Catal Huyuk First Settlements Domestication Key Dates Fact File	Level 4 Greek Civilisation Level 5 Greek Invention Hellenistic Culture Key Dates Fact File Pericles	Level 4 Feudal Europe Level 5 Domesday Book Feudalism Popes and Emperors Fact File	Level 4 Hundred Years War Level 5 Longbow Causes & Consequences Course of the War Key Dates Joan of Arc The Black Prince	Level 4 The Reformation Level 5 Wives of Henry VIII Reformation of the Church Pressures for Reform Luther & Calvin Spread of Protestantism The French Wars of Religion Counter-Reformation Key Dates/ Fact File St. Ignatius of Loyola Catherine de Medici Martin Luther Henry IV Jean Calvin	Level 4 Scientific Revolution Level 5 Clockwork Universe New Science Galileo and the Church Key Dates John Locke Francis Bacon	Level 4 Power & Productivity Level 5 Farming Steam Power Key Dates George Stephenson
Changing Environment Ice Sheets Ice-Age World Key dates	**Germanic Peoples** Barbarian Migrations Tribes and Confederations Key Dates Fact File Attila	**Charlemagne's Europe** Frankish Empire Before Charlemagne Charlemagne's Charlemagne's Rule Key Dates	**Italian City States** The Rise of City States The Venetian Empire Key Dates Cosimo de Medici	**Hapsburg Power** Hapsburg Lands Golden Age of Spain Charles V's Empire Philip II's Spain Key Dates Phillip II	**Protestants & Catholics** Repression and Rebellion Key Dates	**Napoleanic Wars** Napoleonic Europe Flintlock Muskets Waterloo Napoleon's Campaigns Emperor Napoleon

	Alaric	Charles Martel Otto I Charlemagne Hugh Capet		Maria Theresa The Fuggers Francis 1 Charles V		The French Empire Key Dates Fact File Napoleon Metternich
Europe The Myceneans Proud Mycenae Key Dates	Greek City States Greek Expansion Trireme Sparta Government of City-States Greek Colonisation Athenian Democracy Key Dates Fact File 1, 2 & 3 Pericles	Eastern Realms Magyar Kingdom Slav States Kievan Russia Key Dates Wenceslas Rurik Mieszko I Louis II	Africa /Mid East Rise of the Turks Turkish Expansion A New Force Decline of the Byzantine Empire Key Dates Fact File Alp Arslan	Great Voyages Into Unknown Waters Following the Stars Discovery Portugese Success Spanish Voyages Key Dates Fact File 1 & 2 Henry the Navigator Vasco da Gama Christopher Columbus	England in the 1600s Viol English Civil War Fall and Rise of the Monarchy Coffee House Culture Key Dates Fact File Francis Bacon Charles Stuart Oliver Cromwell	The French Revolution Guillotine Reign of Terror A New Order The Eve of Revolution The Role of Paris Revolutionary Key Dates Fact File Napoleon Toussaint-Louverture Marquis de Lafeyette Maximilien Marie Antoinette Georges Danton Charlotte Corday
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Empires of Mesopotamia Great Empires First World Map Babylonians, Kassites & Mitanni Hittites & Assyrians New Assyrian & Babylonian Empires Hammurabi's Code Key Dates Fact File 1 & 2 Suppiluliumas Sennacherib Nebuchadnezzar II Hammurabi Gilgamesh Ashurbanipal	Asia/Australia Hopewell Culture Trade And Tradition Key Dates	Asia/Australia Easter Island Mysterious Statues Rise and Fall Key Dates Fact File	Ming China Voyages of Cheng The Ming Dynasty Life in Ming China Emperors and the Forbidden City Key Dates Fact File Le Loi Hung-Wu	The Maoris Maori Colonists Key Dates	**** (End of section)	Colonising Australia Captain Cook The Convicts A New Country Key Dates Fact File James Cook Lachlan Macquarie

Egypt of Pharoahs Greater Egypt Tutankhamen Phaoroahs at War Old/Mid Kingdoms New Kingdom and Late Period Famous Pharoahs Key dates Fact File Cleopatra VII Ramses II Hatsheput Impotep Amenhotep III Menes Neferiti Akhenaton	Steppe Peoples Steppe Culture Key Dates Fact File	The Polynesians Polynesian Seafarers Polynesian Heritage Key Dates Fact File	Indian States Muslim Conquests Key Dates	****		The British Raj The East India Company British Expansion Key Dates Tipu Sultan Robert Clive
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The Chanin First Cultures in Peru Chavin Culture Key Dates Fact File	Classical China The Silk Road Chinese Invention The Great Wall China Unified The Han Court Key Dates Confucius Wu Ti Wang Mang	China's Golden Age China's Influence Chinese Poetry T'ang Civilisation The T'ang Dynasty The Sung Dynasty Key Facts T'ai-tsung Yang Guifei Empress Wu	Japan of the Samurai Samurai Sword Samurai and Shoguns Domestic Life Key Dates Fact File Minamoto Yoritomo		Moved from left column First Australians * The Peopling of Australia	

	Ch'in Shih Huang Ti					
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The Americas	The Americas	The Americas	1825 - 1914	The Americas	BuildingContents	Clothing	Transport
Asia & Australia	Asia & Australia	Asia & Australia	1700 - 1825	Asia & Australia	Art Contents		
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Asia/Australia **							

Medieval Realms Topology (4 pages)

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Save Text As		Date	Show List - Normal - Tagged record - Linked record		
Save Picture As		Find Word	Display Picture		
Print		Combined Search	Display Text		
			Display both		
			Fit Picture to Window		
Print Preview			Pick Second Record		
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		P = Picture	P 1066 Harold swears loyalty to Duke William
		D + Document	D 1066-1067 Effects of the Norman Conquest: three writs
			D 1066-1075 Writ of William I to the City of London
			D 1072-1075 Trial of Bishop Odo
			and so on 106 records selected
Church	Christendom	List	P 1066-1154 Four Norman Kings
			D 1091-1101 People's Crusade
			D 1095 Pope Urban II calls for a Crusade
			D 1098 Crusader's letter to his wife
			and so on 42 records selected
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			D 1066 Battle of Hastings Version 1 & 2
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WordSearch	All articles including specific word	All articles including multiple words	Search String	Reset	
Category (see below)	Areas of Interest	Physical Science & Geography	Life Science	Geography	History etc
Media+More	Media Types	Animations	Charts	Interactivities	Maps – Details below
Time	Click &drag on Timeline	Or enter dates	Timeline from 15M BC	Timeline to 2000AD	
Place	Type Place Name or choose from buttons	Regions	Countries	Political Subdivisions	Cities
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Alexander the Great	Abolitionists	Immigration	Accra	Aardwolf	Achebe, China
American Revolution	Abraham	Language	Addis Ababa	Aaron, Hank	Acoustics
Animal Behaviour	Achaemenids	Music	Afghanistan	Abacus	Afghanistan
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Acquired Immune Deficiency	Abominable Snowman	Animal	Architecture	Abacus	Aerobics
Adams, John	Abstract Expressionism	Apollo Program	Arizona	Abbey	Aerospace Industry
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Ammonite	Assyro-Babylonian Language	Ajanta Caves	Aaron, Hank	Abenaki	Aaron, Hank
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Arthrodire	Egyptian Art & Architecture	Alans	Abbas, Ferhat	Abolitionists	Abbott, Berenice
Place					

APPENDIX 5

Expert Panel - additional charts
1) Information sent to experts (excerpts from thesis)
2) Expert panel questionnaire
3) Results and Analysis of responses from experts

The discussion and conclusion from the Expert panel is in the main body of the thesis, Chapter 15.16 Navigation Patterns

1) Information sent to experts – this consisted of the following:

Comparative Analysis of three sets of Navigational Patterns

1) **Horney's descriptions, diagram and notes on his patterns, pages 312 - 314**

2) **Parunak's descriptions, diagram and notes on his patterns, pages 315 - 316**

3) **Sue Fenley's descriptions and notes with diagrams (3 pages) 317 - 319, 320 - 322 and formal representation 323 - 324**

1. Horney's Navigational Patterns

Horney (1993) investigated hypertext by looking at the user's experiences and describing the navigational patterns that emerged. Horney referred to users by the term readers and to software designers or hypertext authors by the term author, although he also referred to hypertext authors as users. These 'authors' were creating hypertext and were experts or competent users of the system, but Horney investigated how they used the software and the patterns these experts had chosen to use. Horney's research was one of the most valuable research projects for this thesis as he observed users and then created a series of navigational patterns related to these users. His work mitigated the lack of research on differences in novice and expert behaviour in multimedia and methods of analysing these, as he used experts but defined a very specific method of tracking users, which could be used in further research. One of the problems of his research was that he only used eight hypertext authors or experts which meant that there was a need to expand this user base to see if his sequence of navigational patterns could be applied over a wider skill and ability range. Horney discussed the relationship between these patterns and effective hypertext use. His subsequent work looked at how users worked through software, which is discussed later under working strategies.

Horney employed a software program that allowed each user's exact route to be recorded. This program, called EntryWay[1], had two special linking features - standard binary links and threads, which could be used to link themes or groups of nodes. This gave the user flexibility in the ways users negotiated the nodes. EntryWay navigation allowed four different techniques:

1) Document links - using the Thread, Links and Members menus allowed standard hypertext linking and document links. Pull-down menus accessed the first threads/ binary links/current node.
2) Thread traversal - visit all the thread's members (used for themes or a group of nodes), by activating a particular thread and using Next, Previous and Go commands. A pointer allowed thread traverses, or the navigation of nodes not on this thread, and a return was available.
3) HyperCard functions - such as First, Next, Previous and Last, which were used to move along the stack in the physical linear order of the nodes.
4) Select and Go technique - as each node had a unique name the user could go directly to it, or use the Selection option, and it could be revisited by reselecting it from the Trail menu.

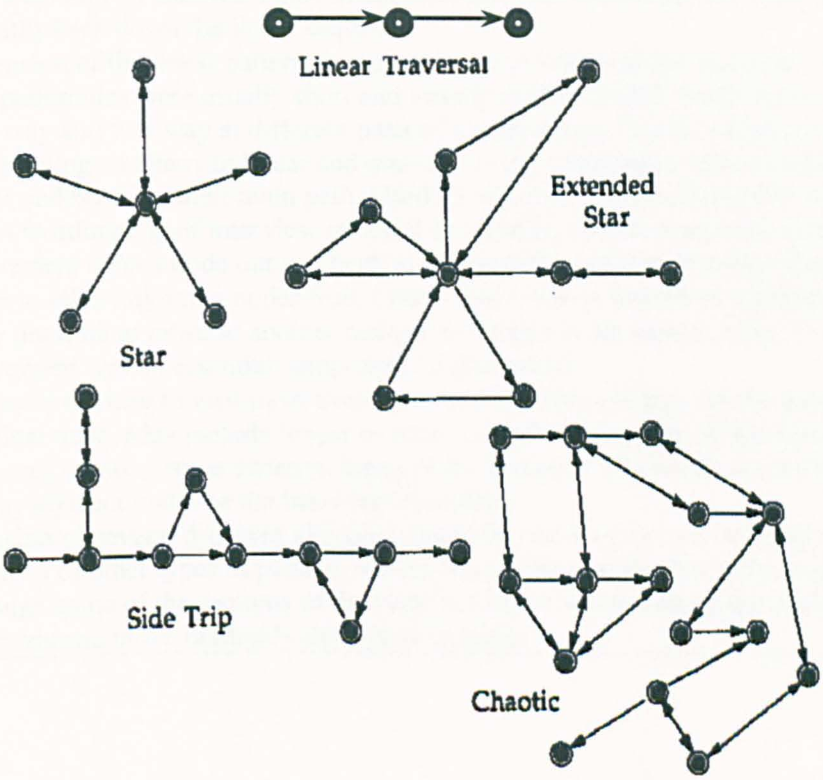
This last technique (Select and Go) was the most powerful one, as authors could traverse from any node to any other node, regardless of any other formal relationship among nodes created by threads and links. In Entry Way each node was explicitly linked to each other. EntryWay maintained a history of the visits to each node, through the Go menu. This allowed access for the researchers to record where the date, time, and method of traversal were recorded for each visit into a node history. These histories indicated each reader's navigational pattern and it was these histories of eight experienced hypertext users that Horney analysed. All eight subjects used EntryWay for their own data collection or research, 1) for mathematics tutor's interviews about long-range goals and objectives in mathematics education, 2) an ethnographic study of a teacher educator, 3) the presentation and questioning techniques of math teachers 4) to collect and analyse laser disk images 5) to create presentations of Chinese poetry, and three subjects created dissertation bibliographies. Using EntryWay for specific tasks in the subject's own work was significant, as this allowed them to computerize and facilitate their work, making their tasks more manageable and productive for the user. By analysing the user histories, Horney identified five navigational patterns, namely Linear Traversal, Side Trip, Star, Extended Star and Chaotic (c.f. Fig 2.1). :

1. Linear Traversal: this was moving in a linear pattern from node to node, user-visited nodes in their physical order

[1] EntryWay was a hypertext authoring extension for *Hypercard.* EntryWay provided for nodes, links and active navigation by readers and recorded each user's trail through a particular piece of software. EntryWay used Threads to link associated nodes and allowed flexibility in traversing the nodes. The system provided a graphical history of each user's path, together with grouped nodes or topics.

2. Side Trip: (a variation of Linear Traversal) this was mainly linear, but with visits to other nodes not on the main path. The use of this pattern was more common than that of Linear Traversal.
3. Star pattern: the user moved from a central node, often called the root node, and returned to this, also seen in map-making activities.
4. Extended star: this was the same as the star pattern, but could incorporate revisiting nodes, primarily through the use of out and back cycles
5. Chaotic: had many different traversal methods and moved through a document at random.

Fig 1 Navigational paths from a navigational report package (after Horney)



Horney stated that the Linear Traversal pattern was the simplest pattern recognised. The Side Trip pattern was described as a variation of the linear traversal one, as it used the same basic linear pattern as the linear traversal but the user made visits to nodes off their main path. The Star pattern was a basic linear traversal, but became a star after the next step, i.e. a return to centre. The essential distinction was that the route changed and allowed the pattern to be re-classified.

The Chaotic pattern represents a random movement through a document, a mixture of patterns or the lack of any specific pattern. Horney did not believe that his Chaotic pattern users were lost, as the users had few significant difficulties in finding their route from place to place. Horney argued that these user's patterns could have been too complex for any more regular pattern to be discernible, and that the Chaotic pattern could be the result of a mixture of other patterns. He extended this concept of the Chaotic as a mixture of patterns by considering that this mixture concept had the potential of being partially true for all the patterns. Few of these occurred in a pure form but they could be mixed together as the needs of the authors or users changed through time. Horney's two linear patterns were frequently used with the Next commands, which moved the users along threads or through Hypercard stacks. The Star pattern users chose Selection followed by the EntryWay command, or Trail to return to the Star's central node (i.e. retracing the user's route back along route). The Chaotic pattern users' employed specific mechanisms (Selection and Input), which allowed navigation outside regular links. Horney outlined his pattern's shapes but did the detail, e.g. giving each pattern exact delimiters.

Fig 2.2 outlines each pattern based on Horney's description. He stated that the Linear Side Trip was a variation of the Linear Traversal.

Fig 2.2 Description of navigational paths (adapted from Horney)

Horney's	Classification of patterns
Linear	Represents a standard and relatively common simple linear movement Examples - long in-order traversals of manuscripts, moving linearly from node to node, Movement was one way with no backward movement allowed, This movement prevents any retracing of paths back down the linear sequence
Side Trip	Extension of the linear pattern, some exploratory routes off the main path were permitted Off path routes were usually short and usually unidirectional, Some variations - both one-way and two-way at different parts of the sequence, Can be excursion to a linked node giving an alternate linear and one-way route, Used when authors make visits to other nodes not on their main path, Used for checking the position of threads and the exact wording e.g. of interview material & could be used to loop back and revisit a node
Star	Movement from a node out and back to the central node or movement from this central node to other adjoining nodes from central node was an important attribute as it was only possible to move to another node with return via the central node. Two way movement was an essential component of this pattern
Extended Star	Allowed the user to visit more than one node before returning, via the second node to the original node, May include longer or more complicated routes off the basic route, Can be one-way or two-way at different times of the pattern, Can include some linear progression along adjacent nodes or the basic star formation
Chaotic	Consists of several different elements, could be one-way or two-way and represent small sections of other types of pattern, Moves from node to node, but paths could be retraced through some of the sections of the pattern, Occurs when authors use multiple traversal methods and move randomly through documents

2. Parunak's Navigation Patterns

Parunak described potential strategies and more relevantly, a series of topologies for hypermedia design. However his work was relevant to multimedia as many of the designer issues were shared between the two fields. Parunak's theoretical perspective was presented in three steps. Firstly he detailed a number of navigational strategies that users employ in physical (geographical) navigation. Secondly he related these to graph topologies, where he showed that restricting the connectivity of a hyperbase could improve the ability of users to navigate. Thirdly he analysed common methods of navigating within hypermedia in terms of both the navigational strategies and graph topologies that users employed. Each of his strategies and typologies were approached from the system designer rather than the user perspective. Although Parunak details both 1) strategies and 2) topologies; he gives no examples of their actual use and has not supplemented his original theoretical work with any empirical testing. He commenced by identifying five common strategies from the geographical perspective: - Identifier, Path, Direction, Distance, and Address.
These strategies Parunak stated were the navigational strategies that humans developed to find their way around the world long before the advent of hypermedia. Parunak's strategies represented components of geographical routes rather than navigational patterns. Parunak's topologies were closer to, more representative and comparable to navigational patterns used to navigate multimedia in the literature than were his strategies, and it was the topologies that were compared to other researcher's navigation patterns.

Fig 2 Outline Diagram of Parunak's topologies (after Parunak 1989)

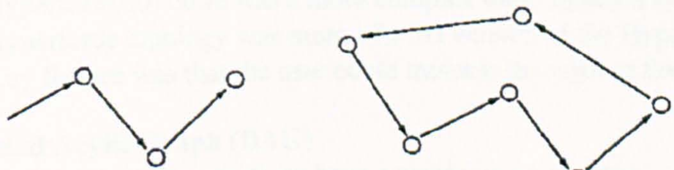


Figure 1: Linear (left) and Ring (right)

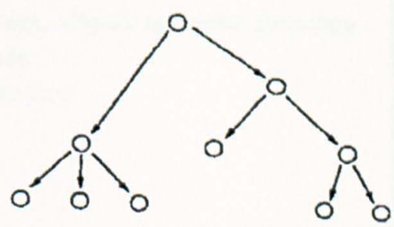


Figure 2: Hierarchy

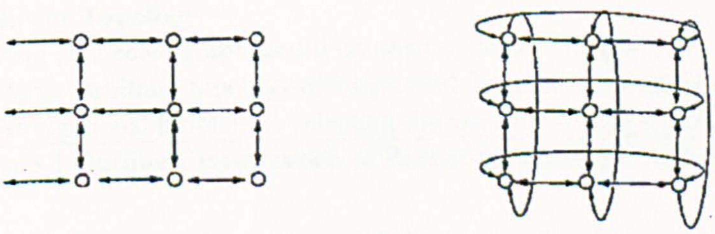


Figure 3: Hypercube (left) and Hypertorus (right)

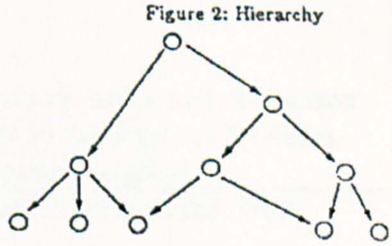


Figure 4: Directed Acyclic Graph

Parunak commented that a small number of alternate routes were easier to use than either a single route or a large number of routes. Although he emphasised that this was unsupported by experimental investigation, his argument was straightforward and persuasive. He believed that no choice limited the user and excessive choice confused or intimidated them, while some choice allowed some route selection.

Theoretical perspective on navigational topologies

Parunak, after describing his five basic navigation strategies, then developed seven topological structures, which linked to his strategies. These topologies were: - Linear, Ring, Hierarchy, Hypercube, Hypertorus, Directed Acyclic Graph and Arbitrary. Parunak outlined a graphical representation of each of his topologies (Fig 3.1 below). Each topologies' attributes are overleaf. Parunak stated that some topologies defined a unique path between any two nodes, and that other topologies permitted multiple paths.

Parunak looked at navigational aids in hypermedia such as beaten path mechanisms, which could be compared to the most used method of navigating and was commensurate with the idea of having a user's history. He argued that links between nodes should be classified and of the need to employ a method of formally linking nodes, as this would allow all links to be analysed and compared. Parunak proposed the use of maps, which would represent levels of structure, and indicate the importance of certain links, as well as providing a geographical/ graphic method of relating the nodes.

Parunak's Topologies
Linear Topology • Specifying that each node has, at the most, one child and one parent • A one-way linear route or a ring • As one parent/one child criteria, there was a necessary directionality, i.e. one way direction
Hierarchy Topology • Initial node having no parents and all the others having one parent
Hypercube/ Hypertorus Topology • More complex still and implies more links within the structure and no restrictions on routes • Two-dimensional structure, which allows two-way movement from and to each node • Hypercube, each node was adjacent to four others, one on each side • Hypertorus structure was a more complex three-dimensional form, allows multiple/ two-way • Hypertorus topology was more of a 3D version of the Hypercube • Key feature was that the user could traverse throughout the structure
Directed Acylic Graph (DAG) • That most implementations have a single point of entry • This would remove all of the hypercube/ hypertorus structure
Arbitrary Topology • Any connected graph, and if no other constraints apply, then only identifier, path & distance • Partial arbitrary topology distinguished from complete arbitrary by the degree of the nodes • Navigational problem in selecting the next node along a path, or next target node

Table 3.1 Outline Classification of Parunak's topologies (adapted from Parunak 1989)

Parunak's linear topology was straightforward and could be related to a common or general and least sophisticated linear pattern. His linear diagram indicated that it was possible to visit different nodes at different levels within the software, but also to simply go directly from one node to another. If the intention was to move from node to node and not to move down in the software, this linear topology could be comparable to a purely linear pattern. If the movement was potentially down into another depth or level then that could represent a star or even a hierarchical pattern (if continued on). The simplicity of Parunak's diagrams could lead to misinterpretations of exactly what movement he envisaged for each pattern. Table 3.1 outlines Parunak's series of topologies with information provided by him for each of the different types. The potential differences in the route were unclear and further development of his series into a definite classification was necessary. There were similar problems with some of his other topologies. In the hierarchy topology all the links pointed away from the root, each node could be reachable from the root, but only in a set sequence and there were no returns or two-way activity in Parunak's interpretation, which did not allow the user to return and then try another linked tree.

3. Sue Fenley's Navigation Patterns

Description of the Navigational Patterns

The chapter lists each pattern, and then expands this basic list into more exact and formalised specifications of all potential pattern types. An outline diagram of a graphical representation of the pattern has been drawn, although these diagrams may not be the only form allowable within each pattern type. The diagrams at this stage serve to give an indication of the type of patterns that may be expected under each pattern type. The first study indicated that basic pattern types could be recognised, although it was difficult to individually assess all the observed routes into the more detailed classifications. Further, more extensive testing is required to support these detailed subdivisions and this is one of the recommendations for future research work. My pattern list has been created by comparing individual or groups' use of multimedia, within some controllable boundaries, and then checking to see if other users have employed similar patterns in the multimedia. This would allow patterns to be amalgamated if necessary and the main series of resultant pattern descriptions made more distinct. However all the user's patterns observed from the first study could be put into these categories. The latter two categories of complex-chaotic and complex-planned provide final classifications for all of the complex or unusual patterns, as well as the very complicated ones, so this potentially means these two pattern types will form unusually large groups. Each navigation pattern description includes information on whether it is one-way or two-way, and how each pattern is different. The first three patterns, linear, linear extra and circular (although linear if insufficient of arc) are straightforward.

1. **Linear** - path on one level, using tools e.g. index, time line, or word search, one direction.
2. **Linear extra** - paths lead away from basic linear pattern, returning to the linear path, usually at the same place or the next node to their original leaving point.
3. **Circular** - initially recognised as linear, but circular when complete, one or two-way, dependent on the software design, may be represented by an ellipse/multifaceted shape e.g. an octagon.
4. **Star** - movement initially linear but implies a change in level, going into second level areas from the first level and returning, one way or two way. Complete star pattern can represent continuous topic selection through the package going into each menu item in turn to the next level and then returning to the starting level, especially with circular or thematic package structures.
5. **Star extra** - a development or extension of the star pattern, movement into the second or third level of the package, i.e. into an additional level, beyond the usual star pattern, one or two way, and the extra depth may only be used for part of the route.
6. **Hierarchical** - movement down the hierarchy, with a possible return along the same path, to go down one or more branches of a tree structure. Progressing one way down the structure and across to the next branch of the tree, can be two-way, but unusually returning to the original starting point, but may retrace path.
7. **Hierarchical -Extra** - movement along multiple hierarchies usually with different subject/themes, usually in the same way, returning to the same tree structure or continuing onto a linked or associated tree. The hierarchical and extra patterns are differentiated by changes in depth and width as the extra extension may involve more than one tree structure, while the basic hierarchical pattern is confined to one tree structure.
8. **Complex - Chaotic** - movement follows a series of different paths, usually in rapid succession, random and erratic navigation, frequent changes of route and searching method, may be a mixture of the above types.
9. **Complex - Planned** - sequence of moves following established path, sometimes including definite patterns, using a mixture of different types, but following an ordered route. Types can be mixed within routes - with some recognition of each type but too confused/short for full classification. The complex patterns are the most difficult to recognize/analyse, as these may be hybrid forms of other patterns or result from rapid use of pattern types.

Navigational patterns in the first study

The navigational patterns listed were recognised in the first study, with the exception of the complex patterns (recognised from previous researchers but need to be empirically tested), which younger students did not use. These patterns are demonstrated below and graphically in Fig 10.1.

1. Linear

In the first study the linear pattern was recognised by the user going through the basic method of using the package, e.g., by following the index. Example: - the user employing the index in Grolier's Encyclopaedia or looking at each item in the main menu in The Way Things Work.

2. Linear-extra

This pattern occurred when the user extended the basic linear pattern, i.e. using the index. The user may employ another linear method e.g. time line and progress along a Timeline, or by reverting back to the original linear progression. Example: - in the Peanuts package, the user starts with the Math package and then the geography one, again in a linear manner.

3. Circular

The user looks at each section or area in turn and returns to the starting point. The circular pattern is often used as part of browsing behaviour, when the user needs to find the delimiters of the package. Example: - in The Way Things Work the user looks at each item in turn, progressing through before returning to the start point.

4. Star pattern

The user looks at the top level of the package and then moves down to the next level. For example -The Way Things Work, the user looks at the main menu and a subsidiary one but visits one choice of this (i.e. one level down) before returning to the main menu and continuing. The star pattern is difficult to differentiate from the circular, unless the user drops down to a different level. There is a difference in classification if the user goes down to another level occasionally, i.e. uses the circular pattern most of the time but occasionally drops down a level. The star pattern is popular with novices and may be the preferential choice of adults who like to check through all sections of a package, often when browsing or getting an initial overview. This pattern with adults may replace the circular pattern frequently used by children. Adults prefer to look at specific subjects in more depth (i.e. +one level) than children.

5. Star-extra

The star extra pattern involves the user going further down into the package before moving on to the next selection. For instance in Eyewitness History, the user looks at each historical period but goes into the next menu before doing the same with the next period. The user may then follow an associated or linked item to extend the pattern beyond the basic star.

6. Hierarchical

The hierarchical pattern is often recognised when the user researches in a particular subject and continues into the subject area. The user may then move down the subject category as if going down the branches of a tree structure, and getting into greater depth. It is also possible for the user to link with associated subjects and follows down links on this. Example: - In Way Things Work, the user selects a subject such as electricity, goes into this subject and then moves onto another associated subject within the same category.

7. Hierarchical-extra

The hierarchical-extra pattern is a variant of the main hierarchical type, with additional searches down adjoining or associated hierarchies. The extra component usually involves more searches and links to associated subjects or involved links with adjoining trees. This searching is noticeable in older groups who are more prepared/ able to do long searches.

8. Complex-Chaotic

The complex chaotic pattern occurs when the user employs several different routes or patterns but for short periods of time and in an erratic way. The complex users are often more experienced users and although aspects of this pattern occurred during the first study it was difficult to see very much of this pattern occurring. Most of the users of this pattern were relatively slow and these slower navigational routes usually allowed a succession of different individual patterns to be recognised from the ones listed above.

9. Complex-Planned

Similarly to the comments on the complex pattern above, although it was considered possible for this pattern to be used in multimedia, the first study did not produce any convincing users of this type. Again as most of them were relatively inexperienced it was reasonably straightforward to assess each of their navigational patterns in terms of the range or mixture of patterns above. The pattern is included in the list for completeness and for use with the second study users, although there are not any examples of its exact use in the first study results.

Further navigational pattern subdivision

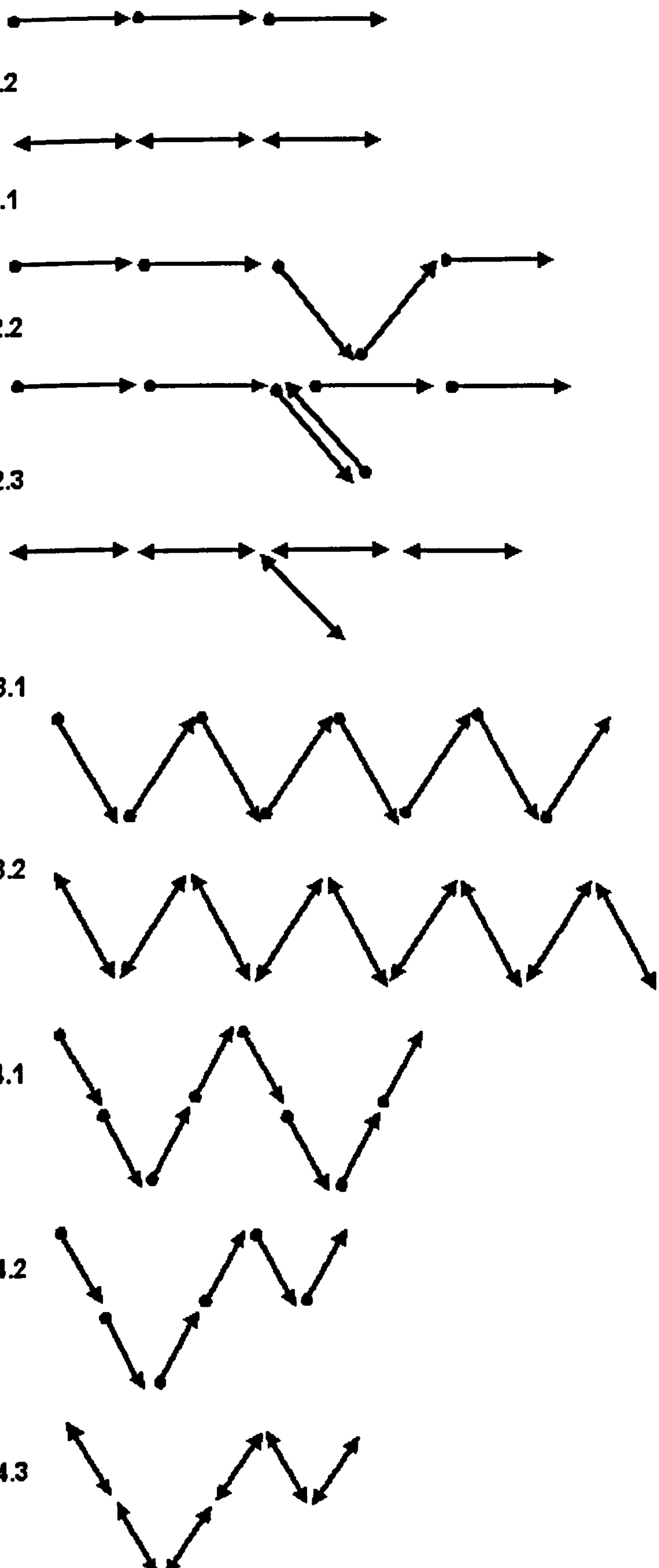
Table 10.1 lists the possible patterns. These smaller sub divisions of patterns (the right column) have been amalgamated into the major pattern types (left column) for the discussion below. These patterns were partially constructed from the routes the users took in the first study. There are extensions for the more complex ones, but these were not used by the children, but were apparent from the small adult sample in the first study. This list of all the potential variations of each pattern type was developed to gauge the number of possible variations along each type of recognised route.

Table 10.1 - Subdivisions in the Navigation patterns classification

Navigation Patterns	Subdivisions
1 Linear	1.1) One way - uni-directional (no return) 1.2) Two way - bi-directional (return possible)
2 Linear Extra	2.1) One way (along path and extended path - no return) 2.2) One way (along path but may return from extended path back to original) 2.3) Two way (path and extended path)
3 Star	3.1) One way 3.2) Two way
4 Star Extra	4.1) Star extra/ Extended - One way 4.2) Star extra – Extended One way + return on extended path only - back to formal star 4.3) Star extra - Two way - star and return on extended star 4.4) Star complete star pattern, with return to starting point
5 Circular	5.1) One way - clockwise - single circle 5.2) One way - anti clockwise 5.3) One way - + multiple circle/loop still one way - not complete - no repeats 5.4) One way - + multiple circle/loop, complete circle, returns to starting point, no repeat 5.5) Two way - but not repeating loops - no repetition of path 5.6) Two way - with repeats on loops - multiple circles
6 Hierarchical	6.1) Hierarchical one way - no returns vertical path - no branching 6.2) Hierarchical one way - branching off same tree - no returns 6.3) Hierarchical two way - vertical tree 6.4) Hierarchical two way - branching off basic tree
7 Hierarchical Extra	7.1) Hierarchical - one way /no returns - vertical branching - possible multiple trees – vertical - unidirectional route 7.2) Hierarchical - one way - loops to other trees - return to main tree 7.3) Hierarchical - two way - vertical branching - more than one tree 7.4) Hierarchical - two way - vertical & horizontal branching - can return – multiple trees
8 Complex -Chaotic	8.1) Complex - unidirectional- no fit to above patterns - or mixture of above 8.2) Complex - two way - erratic - could loop/ cross hierarchies /stars etc. no set patterns
9 Complex - Planned	9.1) Controlled one way route - several search strategies, unidirectional no returns/ loops 9.2) Unidirectional - short loops off main plan, return to set pattern 9.3) Two way - planned includes loops/returns/different patterns-formalised path

Fig 10.1 Graphical representation of the navigational patterns - (overleaf – 3 pages)

NAVIGATIONAL PATTERNS - 1



1.1 Linear - one way

1.2 Linear - two way

2.1 Linear extra - one way

2.2 Linear extra - one way & return along extended path

2.3 Linear extra - two way

3.1 Star - One way

3.2 Star - Two way

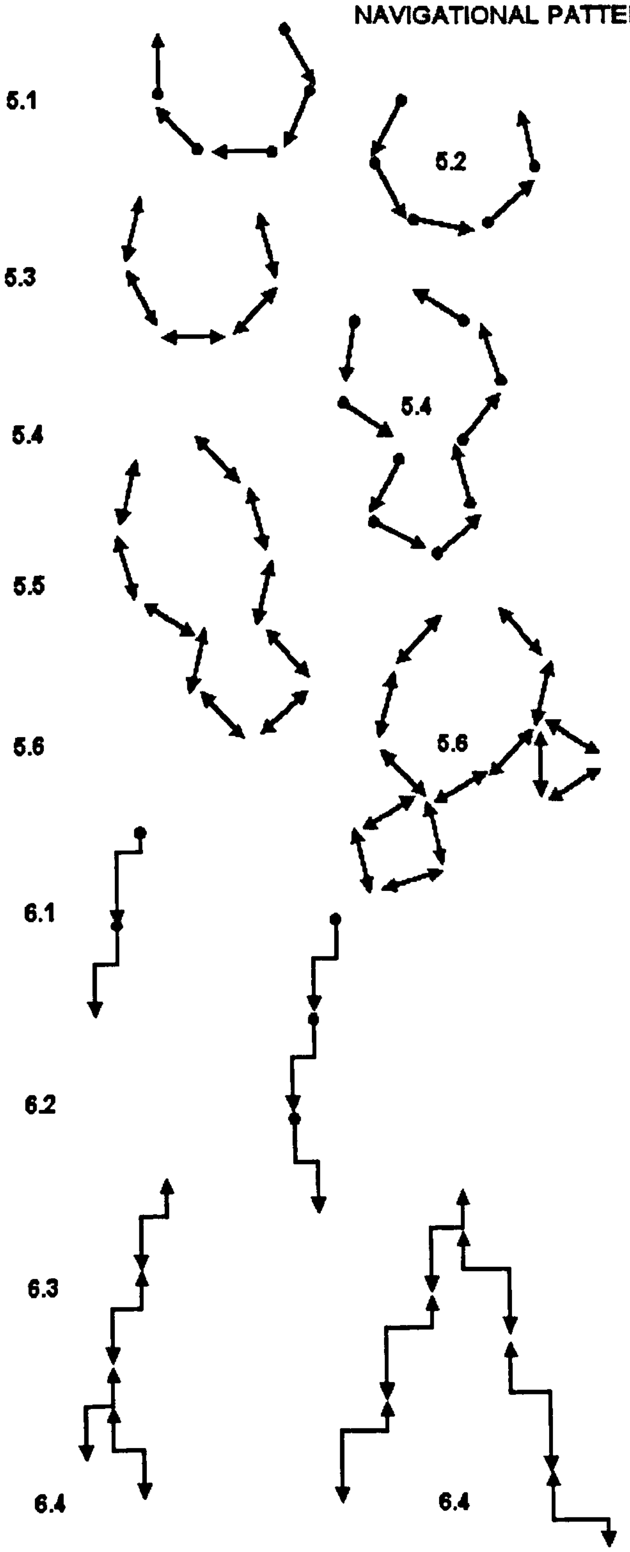
4.1 Extended Star - One way

4.2 Extended Star - One way & return on extended star

4.3 Extended Star - Two way & return on extended star

4.4 Star - complete star pattern, returning to starting point

NAVIGATIONAL PATTERNS - 2



5.1

Circular - one way clockwise

5.2

Circular - one way anti-clockwise

5.3

Circular - two way

5.4

Circular extra - one way

5.5

Circular extra - two way

5.6

Circular extra - two way with additonal circles

6.1

Hierarchical - basic one way

6.2

Heirarchical - simple one way

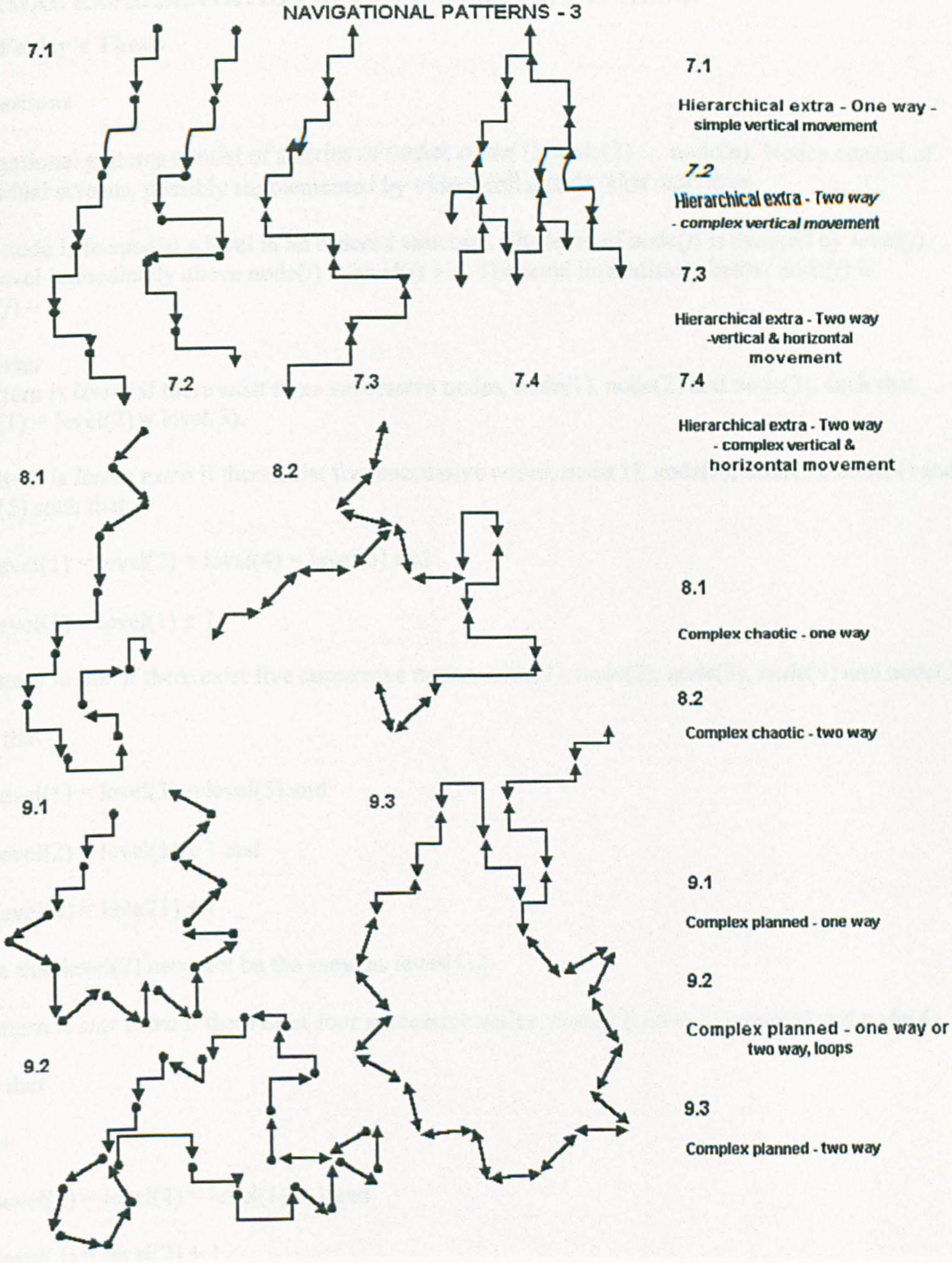
6.3

Hierachical simple - Two way

6.4

Hierarchical simple - Two way & return

NAVIGATIONAL PATTERNS - 3



FORMAL REPRESENTATION OF NAVIGATIONAL PATTERNS

Sue Fenley's Thesis

Definitions

Navigational patterns consist of a series of nodes, node(1), node(2) ... node(n). Nodes consist of individual screens, possibly supplemented by video, collages or other activities.

Each node is located at a level in an ordered structure. The level of node(j) is denoted by level(j). The level immediately above node(j) is level(j) + 1. The level immediately below node(j) is level(j) – 1.

Patterns

A pattern is *linear* if there exist three successive nodes, node(1), node(2) and node(3), such that level(1) = level(2) = level(3).

A pattern is *linear extra* if there exist five successive nodes, node(1), node(2), node(3), node(4) and node(5) such that

(a) level(1) = level(2) = level(4) = level(5) and

(b) level(3) = level(1) ± 1.

A pattern is *star* if there exist five successive nodes, node(1), node(2), node(3), node(4) and node(5) such that

(a) level(1) = level(3) = level(5) and

(b) level(2) = level(1) ± 1 and

(c) level(4) = level(1) ± 1.

[Note that level(2) need not be the same as level(4).]

A pattern is *star extra* if there exist four successive nodes, node(1), node(2), node(3) and node(4), such that

either

(a) level(2) = level(4) = level(1) + 1 and

(b) level(3) = level(2) + 1

or

(a) level(2) = level(4) = level(1) – 1 and

(b) level(3) = level(2) – 1.

A pattern is a circle if there exists a series of nodes, node(1), node(2) ... node(n), such that

(a) level(1) = level(2) = ... = level(n) and

(b) $\text{node}(n + 1) \equiv \text{node}(1)$.

A pattern of nodes, node(1), node(2) ... node(j), on a circle, node(1), node(2) ... node(n) is *circular* if $j > n/2$. (If $j \leq n/2$, the pattern is linear.)

A pattern of nodes is *hierarchical* if there exist four successive nodes, node(1), node(2), node(3) and node(4), such that

either

(a) $\text{level}(3) = \text{level}(2) + 1 = \text{level}(1) + 2$ and

(b) $\text{level}(4) \neq \text{level}(3) - 1$

or

(a) $\text{level}(3) = \text{level}(2) - 1 = \text{level}(1) - 2$ and

(b) $\text{level}(4) \neq \text{level}(3) + 1$.

A pattern is *complex* if it fits none of the above categories.

Comparative Analysis of Navigation Patterns

Please answer all questions by ticking at most appropriate point on each scale (either Very easy to Very difficult or from Good fit to Poor fit) and give comment below

Horney's Navigation Patterns	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
1) Comprehension/ Understanding **Is Horney's scheme easy to understand?**	☐	☐	☐	☐	☐

Comment

2) Ease of Use of classification **Is Horney's scheme easy to use?**	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	☐	☐	☐	☐	☐

Comment

3) Applicability of classification **Does the Scheme fit any Multimedia,** **Or Hypermedia that you know?**	**Very Poor**	**Poor Fit**	**?**	**Good Fit**	**Very Good**
	☐	☐	☐	☐	☐

Comment

4) Formulisation **Is it possible for this classification to be expressed in a formal representation (c.f. SF's formal representation?)**	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	☐	☐	☐	☐	☐

Comment

Comparative Analysis of Navigation Patterns
Please answer all questions by ticking at most appropriate point on each scale (either Very easy to Very difficult or from Good fit to Poor fit) and give comment below

Parunak's Navigation Patterns	Very Difficult	Difficult	?	Easy	Very Easy
1) Comprehension/ Understanding **Is Parunak's scheme easy to understand?**	☐	☐	☐	☐	☐

Comment

2) Ease of Use of classification **Is Parunak's scheme easy to use?**	Very Difficult	Difficult	?	Easy	Very Easy
	☐	☐	☐	☐	☐

Comment

3) Applicability of classification **Does the Scheme fit any Multimedia, Or Hypermedia that you know?**	Very Poor	Poor Fit	?	Good Fit	Very Good
	☐	☐	☐	☐	☐

Comment

4) Formulisation **Is it possible for this classification to be expressed in a formal representation (c.f. SF's formal representation?)**	Very Difficult	Difficult	?	Easy	Very Easy
	☐	☐	☐	☐	☐

Comment

Comparative Analysis of Navigation Patterns

Please answer all questions by ticking at most appropriate point on each scale (either Very easy to Very difficult or from Good fit to Poor fit) and give comment below

Fenley's Navigation Patterns	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
1) Comprehension/ Understanding **Is Fenley's scheme easy to understand?**	☐	☐	☐	☐	☐

Comment

2) Ease of Use of classification **Is Fenley's scheme easy to use?**	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	☐	☐	☐	☐	☐

Comment

3) Applicability of classification **Does the Scheme fit any Multimedia,** **Or Hypermedia that you know?**	**Very Poor**	**Poor Fit**	**?**	**Good Fit**	**Very Good**
	☐	☐	☐	☐	☐

Comment

4) Formulisation **Is it possible for this classification to be expressed in a formal representation (c.f. SF's formal representation?)**	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	☐	☐	☐	☐	☐

Comment

Analysis of Expert Panel

The responses are analysed from the expert panel, which was given to five researchers who were very conversant with designing and or using multimedia. Each of the three questionnaires has been given here with the response from each participant in the relevant boxes for each question. Each researcher has been given a suffix for each question e.g. (01), so that individual replies can be linked. After the four questionnaire pages there is a discussion and some outcomes are given from the panel as a whole.

Comparative Analysis of Navigation Patterns

Please answer all questions by ticking at most appropriate point on each scale (either Very easy to Very difficult or from Good fit to Poor fit) and give comment below

Horney's Navigation Patterns	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
1) Comprehension/ Understanding	0	0	1	2	2
Is Horney's scheme easy to understand?					

The description is not in Horney's own words, therefore my understanding depends on Sue Fenley's description of Horney's classification. I am therefore not assessing my understanding of Horney's scheme directly. In particular, Figure 2.2 contains poor punctuation, making it difficult to understand what is being stated. Nevertheless if compelled to comment on my understanding of this scheme, I would say that I can follow most of it quite easily. The basic categories are easily understandable. The detail is poorly punctuated and I am not sure what is meant by 'pattern'. (Expert 01) – Rating given - Easy
Linear, star, side trip & chaotic – all 'intuitive' shapes that are easy to understand and seem suitable for hypertext navigation patterns. (Expert 02) – Rating - Easy
No comment – (Expert 03) – Rating - ?
This seems quite an intuitive set of patterns. It is interesting that it is taken from observation of actual behaviour. However, presumably user behaviour must be influenced by the options / facilities available – if he had not used the particular software package, perhaps he would have come up with different patterns? (Expert 04) – Rating - Very Easy
Straightforward, comparable to search categorisation elsewhere. 'Chaotic' category badly named (i.e., potentially confounds systematic, opportunistic, and arbitrary behaviours) and 'elastic'. (05) – Very Easy

2) Ease of Use of classification	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
Is Horney's scheme easy to use?	0	0	3	1	1

I can't comment – I haven't used it to classify anything. (01) - 0
Not many categories, so probably not that difficult to apply. The chaotic category would be difficult to recognise (other than as a 'none of the above' category). (02) - Easy
A bit difficult to say fm a theoretical perspective (03) - ?
I'm sorry but I don't understand the question – what would I want to use this classification for? Perhaps for designing educational software? If so, and I establish that most users tend to default to (say) the linear pattern, then this could enable me to design more usable software. If this is what you have in mind, then 'yes' it would be easy to use (so long as I found a way of reliably identifying user behaviour patterns), but it does seem rather over simplified. Also, a lot has happened since 1993, so, with the web, there may well be other patterns around now. Also, I was surprised by the rigidity of the descriptions in Figure 2.2 – e.g. 'no backward movement allowed' – this is poor practice from a usability viewpoint – what happens if they want to remind themselves what is on a previous page? (04) -?
No comment (05) – Very Easy

3) Applicability of classification	**Very Poor**	**Poor Fit**	**?**	**Good Fit**	**Very Good**
Does the Scheme fit any Multimedia, Or Hypermedia that you know?	0	1	1	3	0

I would apply it to website navigation. The description doesn't help me with this, as it doesn't use the terminology or examples of web page navigation. (01) - ?

Yes – even with pretty simple websites I can think of cases of linear, star and side-trip navigation (02) – Good Fit
No comment – (03) – Good Fit
I mainly use the web (rather than educational software). As I commented above, Horney's patterns look as though they could be rather limited and rigid in that context (04) – Poor fit
Very general – but not necessarily as powerful as one might wish. (05) – Good fit

4) Formalisation Is it possible for this classification to be expressed in a formal representation (c.f. SF's formal representation?)	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	0	**0**	**3**	**2**	**0**

I can envisage the basic categories in terms of simple arrow diagrams. The variations in each category seem a bit vague, so are probably hard to formalize. (01) - ?
I'm not a formal representation expert but it doesn't look that complicated (but again the chaotic pattern would be hard to formalise). (02) - Easy
No comment – (03) - ?
This is not really my area (04) - ?
(But to what purpose? Analysis automation?) (05) - Easy

Comparative Analysis of Navigation Patterns

Please answer all questions by ticking at most appropriate point on each scale (either Very easy to Very difficult or from Good fit to Poor fit) and give comment below

Parunak's Navigation Patterns	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
1) Comprehension/ Understanding Is Parunak's scheme easy to understand?	**0**	**2**	**0**	**3**	**0**

Again, my understanding is of Sue Fenley's interpretation/adaptation of Parunak's scheme, not Parunak's exposition in his own words. It includes some phrases that are hard to understand without further explanation, e.g. "restricting the connectivity of a hyperbase". Also I found it difficult to be objective when reading that "his argument was straightforward and persuasive." The specialised terminology used in this scheme makes it difficult to understand, when the terms are not explained. If they were explained, it might become easier to understand. Figure 2 (Outline diagram) was missing from my document. (01) - Diff
Probably not as easy as Horney's patterns but still fairly easy to follow. The hypercube and hypertorus are not very intuitive for me. (02) - Easy
No comment – (03) – Difficult
These are slightly more complex than Horney's and are derived from a designer's perspective. Again they are reasonably intuitive, but I found it difficult to think of examples of when I would want to use some of the more complex patterns such as the hypertorus (04) - Easy
Easy to understand, but not convincing: the hypercube and hypertorus represent odd constraints. (05) - Easy

2) Ease of Use of classification Is Parunak's scheme easy to use?	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	0	**1**	**3**	**1**	**0**

Didn't use it for anything specific, therefore can't comment. (01) - ?
Not that I've tried it, but again the categories are pretty distinct so it should not be difficult. (02) - Easy
No comment – (03) - Difficult
Ditto for Horney's – use for what? If it is for the design of educational software, I would need to think carefully about which pattern to use when. There is a trade-off between simplicity and rigidity (e.g. the linear pattern) and complexity and (relative) flexibility (e.g. the hypertorus). My choices would depend upon a number of factors, such as the nature of the task being carried out (searching for a book would

require more flexibility than ordering a book), and the characteristics of the user. This suggests to me that using these patterns would be quite difficult in reality and would require lots of user testing and prototyping – (04) - ?
Application is problematic. The lack of clarity and incomplete specification (as reported) could make interpretation and categorisation difficult in particular circumstances. (05) - ?

3) Applicability of classification **Does the Scheme fit any Multimedia,** Or Hypermedia that you know?	**Very Poor**	**Poor Fit**	**?**	**Good Fit**	**Very Good**
	0	1	4	0	0

Again application to web pages would not be easy – the terminology is different. (01) - ?
The linear, ring, hierarchy and graph look OK to me, but the hypercube and hypertorus are something I've came across much. (02) -?
No comment – (03) - ?
Ditto for Horney's patterns (04) – Poor Fit
Fit depends on context – applicability and appropriateness of this scheme are potentially problematics (05) - ?

4) Formalisation **Is it possible for this classification to be expressed in a formal representation (c.f. SF's formal representation?)**	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	0	0	5	0	0

I imagine this would lend itself to formal representation, if the detail were teased out. (01) - ?
Probably more difficult that formalising Horney's classification but for people who do formalisation I would imagine it is not that difficult. (02) - ?
No comment – (03) - ?
Ditto for Horney's patterns (04) - ?
Formalisation is potentially easy but relies on improvement of the poor and incomplete specification. (05) - ?

Comparative Analysis of Navigation Patterns

Please answer all questions by ticking at most appropriate point on each scale (either Very Easy to Very difficult or from Good fit to Poor fit) and give comment below

Fenley's Navigation Patterns	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
1) Comprehension/ Understanding **Is Fenley's scheme easy to understand?**	0	1	1	3	0

There is more clarity than in previous schemes and more detail and exemplification. I can't be sure what is meant by 'pattern' here –is it a typical navigational activity, or the way an application is used, or the type of user who does things a certain way? Some terminology used is quite technical (e.g. "insufficient of arc"). I don't think I understand 'linear extra', and the example doesn't help, neither does the diagram. The one-way/two-way descriptions are quite tedious but perhaps necessary. (01) -?
I think the easiest of the three (although I've just read the other two first). It looks like you have kept the most intuitive categories and dropped the others (hypercube and hypertorus). (02) - Easy
No comment – (03) - Easy
These are more complex, partly because there are more of them. Also, I felt a little surprised by what you have done – you have combined patterns derived from users interacting with educational software, with those derived from geographical navigation and imposed in a top-down manner. This is probably OK, so long as both have been properly validated in the context of educational software. I'm not quite sure what your patterns represent – are you saying 'this is what users do' or 'these are the different ways of structuring educational software'? (04) - Difficult
Easy -For the initial version which builds on Horney (?) for extended, more detailed version. I'd have preferred a hierarchical description that clustered the detailed under the initial categories. The main

advantage of this scheme is the description of level changes as well as node transitions. However, the diagrammatic representations are inaccurate in parts (e.g., the star fails to identify the 'anchor' node as a single node visited repeatedly). A suggestion is to use colour to indicate level changes and make the diagrams 2-1/2 D, in order to make the level transitions more salient. (05) - Easy

2) Ease of Use of classification Is Fenley's scheme easy to use?	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	0	**0**	**3**	**2**	**0**

Again, not used for anything specific so can't say whether it's easy to use. Don't know how I would use the 'direction' element. (01) - ?
Probably the easiest in that it looks easy (not having tried it myself). (02) - Easy
No comment – (03) - ?
Ditto for the other two – use for what? If it is for designing educational software, the issue of choosing which pattern to use when would be even harder to resolve. (04) - ?
Potentially easy, although possibly a bit cumbersome. It's not clear to me what significant value is gained by the extra categories – but then I lack context. (05) - Easy

3) Applicability of classification Does the Scheme fit any Multimedia, Or Hypermedia that you know?	**Very Poor**	**Poor Fit**	**?**	**Good Fit**	**Very Good**
	0	**0**	**0**	**5**	**0**

More potential for describing website navigation that with the previous two schemes, due to some relevant examples (but would like more). (01) –Good Fit
Yes – could easily apply to several websites (much like Horney's classification but a bit easier). (02) – Good Fit
No comment – (03) – Good Fit
The sheer complexity of your patterns makes it likely they will fit the structure of the websites I use better. However, it is hard to say anything stronger than that without actually analysing some sites. (04) – Good Fit
No comment (05) – Good fit

4) Formalisation Is it possible for this classification to be expressed in a formal representation (c.f. SF's formal representation?)	**Very Difficult**	**Difficult**	**?**	**Easy**	**Very Easy**
	0	**0**	**2**	**3**	**0**

I don't find this type of representation helpful as someone coming fresh to this scheme, but I imagine it could be a useful shorthand for someone very familiar with the scheme who is using it to classify navigation activities. (01) - Easy
It looks possible – you sent me your formal representation, which seems OK to me. I guess it would be nice to have a program count these patterns in a web server's log file – this may not be very hard given your formalisation. (02) - Easy
No comment – (03) - Easy
Ditto for Horney's patterns (This is not really my area) (04) - 0
Notionally she's done this! (05) – No score

APPENDIX 6 – User Comments
User comments – Study 1
User comments – Study 2

Study 1 user comments - User comments on Navigation

Direction/ Route	Comments included where to go next, or which choice to follow, or making joint decisions on the route. Students spent variable amounts of time discussing the route, sometimes non-verbal communication or minimal talking techniques, pointing, simple commands
Design	Few design issues discussed such as 'why is it like this?' Few comments made on the software design. This may Little awareness of possible alternatives or of other multimedia designs- not surprising. Most students accepted the design or set up, didn't criticise it – a) unfamiliar with multimedia, b) programs previously used were less sophisticated, without favourites: - video sound, animation, or full colour.
Other Media Use	Multimedia software relates more closely to their television viewing rather than schoolwork. Television regarded as fun, computer programs previously used more basic and closely linked to their schoolwork.
Pair conflicts	Conflict if different individual navigational preferences. Rare to have single consistent pattern of approach for each pair, - all different, based on personal preferences. Some very critical of their partner's navigation, especially revisiting any location, especially true for Workshop areas (Way Things Work) and Quiz section (Eyewitness History of the World). Misconceptions about what the actual subject areas contained, and in certain features, e.g. with the Inventors section in the Way Things Work, which they found too textual.

User comments on the software used

General Comments	Comments relate to features they had used and liked, problems using the software and how to improve it. More options needed and information on what available, - perceptive comments from young/ inexperienced students.
Layout	Some students good concept of design, or how it should be designed, e.g. an integrated concept with all sections linked together. Several comments on preferences between the software and features that were better in one, or were needed by other software.
Specific software	Eyewitness quiz problematic – as addictive Two older groups spent significant time on this. Both groups + dominant males, acquiescent females, but both females joined in. Both reasonably high ability and hence managed to answer most questions Students on their own tempted by the quiz rather than work, and restrictions needed on Quiz use in school environment. Comments on Medieval Realms, children thought needed list of the topics available from the beginning.
Motivating aspects	Use of quiz highlights motivational benefits as children's interest and wish to use aspects could be tailored into educationally beneficial multimedia, which entertains as well as teaches.
Software Limitations	Secondary students were more aware of the software limitations, e.g. lack of detail on each subject or the small amount of text. Comments were made on the packages' shallow approach especially in packages such as Eyewitness; this viewpoint was especially prevalent with the adults, as, when interested in a particular subject little development beyond a few simple screens.

User comments related to the tasks

Task sharing	Comments were either concerned with the exact task or were more general comments about the type of task, how to share between the pair, and if they needed to take turns. Some pairs very interested in turn taking and their comments show concern in this and being fair, especially in the middle group. Most of the groups shared reasonably well. Others had one dominant and one less interested partner, or both partners were willing to participate as a pair, show interest or concern about the other's path.
Requests for help	Some pairs kept asking for more information on the task and wanting help. Again this was more prevalent in the younger and to a lesser extent the middle group rather than with the older students. Some wanted more help and expected the observer to help them and to effectively do the task for them, possibly due to unfamiliarity with the software or lack of confidence and when they were told to do it with the minimum of help they all managed to do it.
Success/ Time taken	Success and the time taken varied between the groups. Many of the students wanted specific instructions or guides which would give them exact directions and 'what to do if' scenarios, so

	as not to waste time. If the user is following a set worksheet, the software could be designed to give this sort of prompt if the student becomes lost or stationary.
Students competency	Most students competent at using the computer, younger ones experienced significantly more difficulties through unfamiliarity, lack of experience and skill. Older children worked better together and problem solved together more efficiently, and started on the task more quickly, but more used to this method of working.
Gender issues	Most single sex groups worked well together, but the younger mixed pairs often had dominant and controlling male partners. In the older groups there appeared to be less friendship and more politeness with the mixed sex pairs than in the single sex pairs.
Friend groups	Friendship groups, i.e. children who frequently worked together, worked well in this situation, while those unfamiliar with their co-partners spent time establishing the pair and negotiating more.

User comments relating to requests for help and information

General points	Amount of help required was very variable, all students were given basic instructions, and younger ones needed the most help. Older students resolved problems themselves – but took long time, would try all options, before asking
Help facility	Relatively few questions on help, little use of on-line help, Queries usually on completing task, few on navigating
Require-ment for help	Younger groups wanted and expected more, from adult not computer. Usually given help by adult, used to this & new to multimedia. Younger children needed even more teacher assistance when using multimedia

Post observation interview - student assessment

Younger group	Using the multimedia packages difficult, many novices, and mouse control awkward. Packages used needed text read, children found this hard. Used packages simply, unaware of structure. Liked The Way Things Work, but Grolier's Encyclopaedia too difficult, - not designed for children comment. Some with little concept of what required, expected to be told explicitly, most enjoyed session and learnt from it. No concept of ways to improve software and disliked/couldn't conceive layout task
Middle group	Enjoyed the session, a few needed help, others didn't want help, most liked browsing. Two became bored and wanted to finish, rest prepared to keep going. Packages easy to use and completed most tasks. Views on which software they preferred. Not aware of the structure of the programs and some interest in other groups choices. Some considered able to complete on own, not need teacher input
Older group	More confident and competent than other groups, most had multimedia experience. Had preferences for certain software generally preferring more graphically presented Eyewitness History package than Medieval Realms perhaps because Eyewitness one was easier to use. Opinions varied on browsing and how easy the packages were to navigate. One group commented Eyewitness was not meant for adults, whereas Medieval Realms was designed for the adult. Most had suggestions for improving the software, all prepared to think about the layout and attempt to represent it.

Student views, responses and preferences

The students' views and preferences for certain software seem to be based on the ease of use. Some of the interfaces seem to have set age ranges where the appeal to the particular group of users. For instance the Peanuts program and The Way Things Work seem to have very definite cut off points, where the children thought the interface was too young compared to the content. Some packages had a more general appeal, such as Eyewitness, which was liked by most groups, but packages such as Medieval Realms were considered too difficult to use. Other packages e.g. Grolier's Encyclopaedia had a mixed reception and this seemed to be based on what areas the children had looked at and how enthusiastic they were about it as a pair. Responses and methods of use were very varied, although there is similarity across the type of preferences they chose. Younger children would frequently select pictures or video and be disappointed if a particular section did not have any, with fewer of the younger and middle groups spending any time reading the text. The older group however did read a lot of text and found the Eyewitness text poor and too brief, especially if they had previously used the larger text resource of Medieval Realms.

Study 2 User Comments

Post -test comments on Task 1

Opinions on Task 1 were very varied. Three users enjoying it (1 Intermediate, 2 Novice) as they could wander around at will, while another commented that the session was more important than expected, as it was useful to explore different search modifiers. Often users thought it formed a useful orientation or introduction. Others felt that it allowed them to browse menus, that it was quite naturalistic and enabled them to understand what to do, and that it was necessary to find their way around package.

Post -test comments Task 2

The comments for Task 2 were usually positive, with suggestions that this task provided necessary structure, and that it was a good idea as a beginning for starting a package. Users also commented positively on the Timeline route. A few users however were not sure about this task or what to do, although they said that they had followed instructions but would have preferred to find relevant topics themselves. Others were confused because they could not find what they wanted.

Post-test comments on Task 3

A few of the users found this to be the most problematic of the three tasks. Reasons related to the lack of hypertext links and the need to resort to the search tool. It was difficult to think of a topic whilst it was felt that suggestions would be helpful, that it was a useful tool and that they prefer to use Encarta for a specific task. The reasons given for this were that they had trouble starting and knowing how to find useful information especially as time was restricted, although others preferred being able to direct themselves towards a real question. Some users found information quickly; others enjoyed the task but thought they should have chosen something they did not already know about. Positive comments included that it was easy to use, that the notepad and word processor were good, and it was enjoyable and that it was useful to have an opportunity to pursue their own interests.

Post-test questionnaire, comments on knowledge, structure of the package and strategies used.

Some users stated that they had relied on prior knowledge; others had exclusively used prior knowledge for their searches, while others stated that they had no previous knowledge of specific material. The question on knowledge and learning gave interesting responses, ranging from saying what they had learnt to that they had not gained any knowledge. Those that specified what they learnt included various subjects such as the Roman Empire, a symbolist painter, Rome, Cleopatra, Egypt, and Great Wall of China among others. Comments on the structure included one that the structure was basic, others that they relied on tools like the Timeline. There were general comments on the package being like a database of searchable entries. There were variable responses as to how easy it was to determine the structure of the material, while others noted that a history of where they had been would have helped. Particular features they would use, such as the Timeline, Table of contents and a Set article, were mentioned although there was some overlap with the navigation question. Users were however often very certain of their strategies, but the comments showed that others were less sure.

General comments from post test questionnaire

Analysis of the post observation questions on Encarta indicated that users either liked it, had reservations about it, or they disliked it. The positive comments from users were that it was easy to use, the hot text links were liked and it was a good encyclopaedia. The more qualified response included comments that the user would have liked a proper history and introductory guide, that the package needs a specific aim or purpose, and that it needed better search tools, with less high level navigation and more work on placing the material in context. The negative comments were that it was difficult to search a subject in depth, there was little explanation of features such as the search wizard, and other design features were ill thought out. The design itself was described as poor; and Encarta failed to meet the user's expectations.

Post test questionnaire, the areas looked at and the user's personal preferences

Most of the users specified that they had only seen a fraction of the content but thought they had looked at most of the features and used a good proportion of these. One user thought they had looked at 60% of what was available. Sometimes the amount of scrolling was inevitable with the wide scope of the information, and the search tools were not thought sophisticated enough with this much information. If the users had been asked to complete a formalised pre and post test assessment of learning, which would be needed to fully assess outcomes of learning, this would have conflicted with the main aim of this research, to investigate the navigational patterns. As a full pre-test would have conditioned user's navigation, how they chose to use the software and their chosen navigational routes (cf. Hawthorne effect).

Comments from the poor recall, medium recall and good recall groups

The poor recall group remembered small sections of what they had looked at, but this was limited and often incomplete. They produced broad categories but little detail and no specific areas that they had covered. A few remembered very little, while one user admitted remembering little about the Romans but more about the free task. The various comments from this group included the suggestion that they needed a specific reason for a search for it to be useful. One user felt that recall would be limited, as it did not cover their prior knowledge or interests. Three users only remembered part of the session, while others remembered headings but not content. Other Experts comment on the poor quality of the software, which made them concerned about how useful or positive the experience had been and hence the need or benefit of recalling it.

The medium recall group again generally had a broad outline of what covered. They recalled less on the set task than the open choice. Specific questions, such as those on the Roman emperors (see Appendix 1 for Questionnaires), provoked a poor response. Most of these medium recall users however did remember names and facts, however they were not all sure if this information came from the session or their prior knowledge. Users thought they would have remembered more on the Romans if they had been prompted, whilst they remembered their own search (in Task 3) very well. The comments from this group related to recall, time limits and an idea on the sort of prior knowledge they had used. There were comments that they would have retained more if it had been more detailed and interesting.

The good recall group usually remembered significant aspects of each of the tasks, often in great detail. This may have depended on how easily they usually remember searches and often they remembered them in the same sequence as they had originally used them. Most of these good recall users were very comprehensive. This entire group had a good coverage of the tasks and the areas covered as well as their navigation routes through each of the tasks. This group was fairly critical of their own abilities to recall, which was surprising considering they were the most successful at this. However a few of these good recall users had found similar problems to other groups and comments were also made on the tedious format of the text and that prompting may have helped recall.

General comments from the follow up interviews

The comments from the follow-up questionnaires have similarities across the groups and a few relevant points can be made from them. There was generally better recall for their own subjects rather than for the set route (Roman) area. Thus recall may also be dependent or related to their own interest level in the subject matter and again their prior knowledge. There is little relationship between the different types of recall and the Expert to Novice groupings. This would suggest that the user's expertise levels did not help to recall the content. It could be argued though that a developed knowledge and understanding of the package's structure (as with the Experts) would have helped reconstruct the task and the navigational route taken by the user. Equally the reverse condition could aid recall for some users, because it was a new package or experience and Novice users in particular were enthusiastic about the package. Users also often remembered the structure of the package and how they navigated in it more than they recalled the content. This may be a reflection of their usual job duties, especially for those Expert users developing computer software.